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CORN AND CORN GROWING

5th Edition revised by

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PREFACE

The first four editions of *Corn and Corn Growing* have been exhausted. In response to a continued demand, the book has been completely revised for the fifth edition. Many changes have been made throughout the book. Additions to the history of corn include some information not previously published except in scientific reports. Much emphasis has been placed on the tremendous changes in corn-growing practices since the previous edition. These practices have been generally introduced in the more important corn-growing areas in the United States because of greatly increased use of hybrid corn and the adaptation of mechanical equipment on farms. Added material has been included because of the increased application of fertilizers for the growing of corn. New chemical methods have appeared for controlling weeds and insects. An increasing number of manufactured articles utilize the grain and parts of the corn plant as a source of raw material.

In Chapter XXVIII the available figures have been brought up to date, and new material has been added. These changes and additions were made in the hope that this fifth edition will be more useful.

The authors are indebted to Leslie Carl, H. C. S. Thom, and many other individuals for very helpful suggestions and contributions.

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CHAPTER I

HISTORY OF CORN

The origin of corn is still a mystery. In spite of much modern work on the subject we have as yet no definite proof as to where it came from or when. It was certainly highly developed in the New World long before the time of Columbus, and its presence here for at least a thousand years previous to the discovery of the New World is now authenticated by numerous specimens from prehistoric tombs, camp sites, and trash heaps. However, we now know enough about the skill of the early navigators in the South Pacific so that we cannot definitely rule out the possibility of an Asiatic origin and an early transfer across the Pacific, particularly since corn is widely grown there, especially by primitive peoples.

Though the mystery remains, there is a strong probability that it may not be one much longer. The problem is being actively investigated from a number of angles, and before many years we should be able to have definite proof of the original home of corn.

If, as seems most probable, it originated in the New World, three regions are more likely than any of the others:

1. Central America (Guatemala or Mexico).
2. The highlands of Peru.
3. The western edge of the Amazon basin.

Central America was favored as the possible homeland, largely because of the presence there of teosinte, a weedy grass with which corn crosses readily. Mangelsdorf and Reeves' studies of teosinte (see Chapter V) have made it seem more probable that this area was a secondary center in which new

types of corn were developed after it had originated elsewhere. On theoretical grounds they suggested the Amazon basin as a more likely place of origin, and H. C. Cutler's collections of remarkable and varied primitive varieties from that region have lent force to their arguments.

If we do not know where corn originated, at least we have more detailed information about its occurrence in prehistoric times than we have for any other New World crop. As a subject for archaeological investigation, corn presents a large woody cob which resists decay, which chars easily into relatively imperishable charcoal, and which possesses a large number of diagnostic features for examination and study. When all the archaeological material of corn already in museums is measured and described, we shall have a more complete history of the development of corn than will ever be possible for any other crop plant. The archaeological record is tantalizing, because it is so rich in some spots and altogether lacking in others. The most complete collections come from semi-desert areas like coastal Chile where there is little or no rainfall but where there are oases on which corn can be grown successfully. From the northern coast of Chile and much of coastal Peru there are hundreds if not thousands of archaeological specimens of corn already in our museums, and many more are being added every year. They come from tombs and from ancient trash heaps, some of which were excavated layer by layer so that we can know for certain which were the earlier types and which the later. For this part of the world we have an archaeological record which is at least one thousand years long and probably longer. In coastal Chile and Peru corn appears suddenly along with pottery and weaving and other advanced traits. These earliest varieties were relatively small and uniform. Cobs and kernels were small like popcorn. Bags of popcorn flour and fluffy white popped kernels demonstrate that these early varieties really were popped. This general type was present over a wide area for centuries. At a much later date, but still in pre-Columbian times, large-

kerneled, heavy-cobbed varieties, scarcely different from modern Peruvian corn, appeared in the region.

Wherever or whenever corn originated, by the time the New World was discovered it was grown over much of the area from southernmost Chile to southern Canada and from east to west, at altitudes from sea level to higher than 12,000 feet. At the northernmost edge of its range in New England and Canada there was mainly one type, although several color varieties were included. Farther to the south in Mexico and in the Andes corn existed in a profusion of varieties belonging to different major types and was used for a variety of purposes.

The early literature concerning the first corn seen by Europeans is mostly in Spanish and Portuguese. It is widely scattered and some of the most important documents, though centuries old, still exist only in manuscript form. When thoroughly sifted these documents will give a brilliant and dated picture of what corn was like in the New World in the early years. From the relatively little that has been published, we know that corn was at the very heart and center of pre-Columbian life, particularly in Central America.

Economically, corn was about as important as all the other food plants put together and had also become the center for many religious observances. Tlaloc, the Aztec god of corn, was also in one or another aspect the god of fertility, the god of rain, and the god of harvest. Pictures of corn were painted on the temple walls; it was sculptured in stone; and corn tassels, ears of corn, and even corn pollen played a conspicuous role in many ceremonies. Corn's uses were many and varied. There were special varieties for popping, others for brewing, and still others, of a dark purple color, were used as dyes and for coloring other foods. Special varieties were developed that could be eaten green on the cob, though apparently in most of Central and South America these were not actual sweet corns. Such corn did exist, however, and played an important role in a continent which had not yet received sugar cane. Sirups and wines were made from the stalk of

certain varieties and other kinds were grown especially for their use in religious ceremonies.

Corn foods were universal and varied. There were tortillas and other corn cakes, baked on hot griddles. There were gruels, hot or cold, some with and some without meat. There were tamales of various sorts, cooked in the husks of the corn plant. There were pinoles made by parching or popping corn and grinding the kernels into a fine powder. There were special cakes made from corn pollen and a whole set of particularly delicious foods prepared from the grated kernels of the ripening corn.

EARLY HISTORY IN AMERICA

Early explorers in what is now the United States mentioned the large fields of corn cultivated by the Indians and remarked about the slowness of Europe to adopt this new grain, which they considered so valuable. Columbus first saw corn on November 5, 1492, on the island of Cuba. In 1498, Columbus reported that his brother passed through eighteen miles of corn on the Isthmus; in 1605, Champlain saw a field of corn at the mouth of the Kennebec River; in 1609, Hudson saw many fields along the Hudson River; and, in 1620, in Massachusetts, Captain Miles Standish reported a field of 500 acres that had been cropped the year previous. Drawings made by Hernandez of corn which he found in Mexico, about 1600, show the plant with three or four ears on the stalks, and ears with eight or ten rows.

Thomas Hariot, a member of the ill-fated Virginia colony of 1585, wrote in 1588 what is probably the first extended English description of corn as grown in what now is the United States. He stated:

> Pagatour, a kinde of graine so called by the inhabitants; the same in the West Indies is called Mayse . . . The graine is about the bignesse of our ordinary English peaze, and not much different

in forme and shape, but of divers colors; some white, some red, some yellow, and some blue. All of them yeelds a very white sweete flowre; being used according to his kind it maketh a very goode bread.

On November 16, 1620, a group of Pilgrims landed on the Plymouth coast and spied five Indians whom they followed all that day. The next morning, they "found new stubble where Indian corn had been planted the same year." Near a deserted house "heaps of sand newly paddled with hands which they digged up and found in them divers fair Indian corn in baskets, some whereof was in ears, fair and good, of divers colors, which seemed to them a goodly sight having seen none before."

The most important history of corn in this country as far as the white man is concerned began with the settlement of Jamestown in 1607. The colonists had a hard time to keep from starvation, and had it not been for the corn obtained from the Indians the colony would probably have failed. The Indians taught the colonists how to prepare the ground and plant the corn. The trees were girdled, the ground stirred, and the grain planted in hills three or more feet apart. In places on the New England coast it was necessary to fertilize the ground before it would produce a crop. The Indians showed the colonists how to fertilize with fish. Herring or shad, which came up the streams by the thousands in the spring to spawn, were caught, and one fish was placed in each hill of corn. One writer of the time said that it took about a thousand fish to plant an acre of corn, and without fish no corn was planted. He also stated that an acre of corn planted with fish yielded as much as three acres planted without. There is a tradition about putting a fish in each hill of corn. A law was enacted requiring that every dog should be tied up by the hind leg immediately after corn was planted. He was kept so tied until the corn crop had utilized the major portion of the fish.

Most writers speak of flint corn and sweet corn as being grown by the Indians. Gourdseed varieties were grown by the early southern settlers. The dent varieties today are the result of both accidental and intentional crossing, particularly of gourdseed and flint types.

The Atlantic Coast farmers from 1800 to 1840 made a real effort to get high-yielding strains of corn. The farm papers of 1819 to 1822 tell of several instances of getting Maha (undoubtedly Omaha Indian) corn from Council Bluffs—now a part of Iowa. This corn was an eight-row soft-corn type, and several of the eastern farmers claimed yields of more than 100 bushels to the acre. The Sioux yellow, ten- to twelve-row flint corn, was introduced from the west by several growers, and there were several introductions of a Canadian flint corn. These introductions, together with the local varieties, are probably found to some extent in most of our modern varieties and help to explain the heterogeneous nature of our present-day types.

ORIGIN OF CORN BELT DENTS

Out of these mixtures the productive yellow dent varieties of the American Corn Belt eventually developed. Most of their characteristics trace back either to the crescent-shaped (wider than long, thickest at outside edge), yellow flints of the north, or the soft, white, many-rowed, southern varieties, such as the gourdseed. In Colonial times and later, northern flints were universal throughout New York and New England and were commonly grown much farther south, as they had been by the Indians before the colonists arrived. As early as the nineteenth century, flint corns were still among the commonest kinds in central Illinois. These northern flints as shown in Fig. 1 had wide kernels in eight to ten rows and long cylindrical ears. The southern gourdseeds were late-maturing, rank-growing kinds with row numbers up to twenty-two and above, and a white kernel so deeply dented that it was often collapsed at the tip, as shown in Fig. 2.

Some people have looked on the gourdseed as being synonymous with dent corn. That this is not true is indicated by the testimony of farmers who grew both dents and gourdseeds. For instance, one farmer who grew both wrote:

> Gourdseed is a large, rough, soft corn. It is later and has larger stalks and ears than the other varieties. It lacks the flintiness and weight for the same bulk as the others have. In comparison with dent of my own raising, in feeding hogs, I thought it took about one and one-fourth bushels to go as far as one of my own corn. But cattle in particular will eat it more readily, as it is not so hard to masticate.

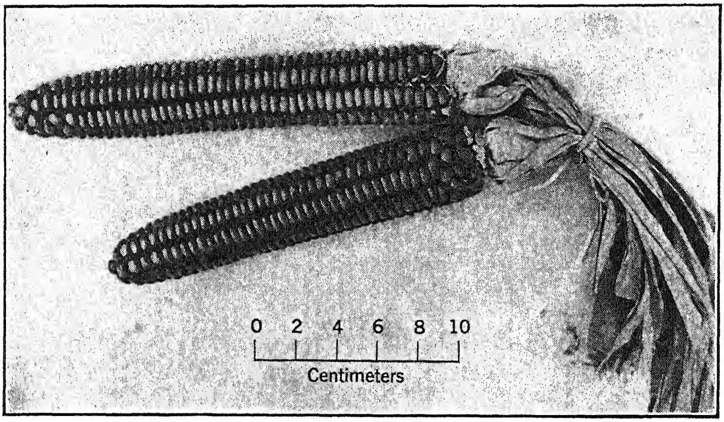

FIG. 1. Northern flint corn. (Courtesy W. L. Brown.)

Mr. John Lorain, in his *Practice of Husbandry*, published in 1825, referred to the common practice of mixing gourdseed with other varieties:

> So prevalent are mixtures that I have never examined a field of corn (where great care had not been taken to select the seed) which did not exhibit evident traces of all the corn in general use for field planting, with many others that are not used for this purpose. None can be longer nor more readily traced than the gourdseed.

The quantity of the gourdseed mixed with the flinty yellow corns may be determined, so as to answer the farmer's purpose. When the proportion of the former greatly predominates, the grains are

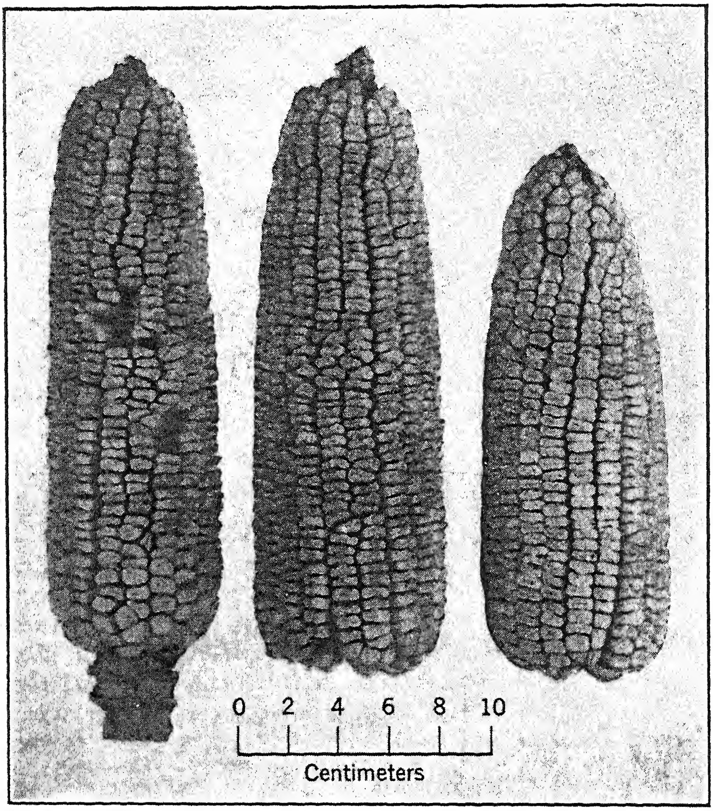

Fig. 2. Southern gourdseed. (Courtesy W. L. Brown.)

pale, very long and narrow, and the outside ends of them are so flat (beaked) that but little of the indenture is seen. As the portion of the gourdseed decreases in the mixture, the grains shorten, become wider, and their outside ends grow thicker. The indentures also become larger and rounder, until the harder corns get the ascendancy. After this, the outside ends of the grain become thicker and more

circular. They also grow wider, and the fluted appearance between the rows increases. The indentures also decrease in size until they disappear, and the yellow, flinty variety is formed, but as I believe, not so fully but that the latent remains will forever subject it to more or less change. It is more difficult to determine the quantity of big and little yellow flints, which may happen to be mixed with the gourdseed, and at the same time with each other. The soft, open texture of the gourdseed renders it unfit for exportation, unless it be kiln-dried.

Lorain, previous to 1825, stated that true gourdseed is white:

It is invariably white, unless it has been mixed with the yellow flinty corns. Then it is called the yellow gourdseed, and too many farmers consider it and most other mixtures original corns. I have often heard of original yellow gourdseed corn, but after taking much trouble to investigate the fact, could never find anything more than a mixture. If there be an original yellow gourdseed corn, it has eluded my very attentive inquiry from the Atlantic to our most remote western settlements.

Lorain also said that much of the corn which passes for white gourdseed has been mixed with white flint.

Peter A. Brown, writing a paper on corn for the Chester County, Pennsylvania, Cabinet of Natural Science, in 1837, referred to true gourdseed as carrying twenty-four or more rows of kernels. He looked on ears carrying fourteen to twenty-two rows of kernels as mixtures of flint and gourdseed. No reference was made to dent corn, although he listed thirty-five different types, seven of which he stated were originated by mixing gourdseed and flint.

From the U. S. Patent Office report for 1850 we learn the replies to a questionnaire sent out over the country to leading farmers. It asked, among other things, "What varieties of corn are most esteemed in your vicinity?" and the answers for this particular year, printed without being summarized in any way, gave a detailed picture of the kind of corn grown in the United States in the middle of the nineteenth century. The Corn Belt was just then taking shape in Ohio. Three of

the replies from that state described the mixing of flints and gourdseeds which was taking place. "We cultivate several varieties of what is here called gourdseed. They are all nearly a hybrid between the rough gourdseed of the South and the flints of the North." Another letter asserted that the best varieties are "obtained by mixing the large southern corn with that of the North." Another stated that there are "many good varieties, mostly crosses between gourdseed and the small flint." Only one reply about corn was received from Illinois, which was then outside the Corn Belt. It reported that in the vicinity of Quincy the most esteemed variety was a "species obtained by mixing the large yellow corn of Kentucky with the yellow flint." The white gourdseed was also said to be planted. Mixtures of gourdseed with various southern corns were specifically mentioned in reports from North and South Carolina, Virginia, Alabama, and Mississippi. Northern flints alone were mentioned for Maine, New Hampshire, Connecticut, and New York, and they were still among the outstanding varieties for Massachusetts, Ohio, Kentucky, Illinois, and Michigan. In this 1850 report, incidentally, the expression "dent corn" was used only in the three letters from Michigan.

The new varieties of Corn Belt dents which originated from this prolonged and complex mixing got their long cylindrical ears from the flints and their soft kernels from the gourdseeds; their row number was intermediate between the two varieties. The clear, yellow kernel color came from the flints, but it was intensified by the red cob brought in from gourdseeds and additional southern varieties. Extremely variable at first, the varieties became more standardized under the rigid selection for type during the reign of the corn shows in the later nineteenth and early twentieth centuries. It remained for the yield test to select the most productive kinds of this mixture and for hybrid corn to make really efficient use of the germ plasm present in the Corn Belt dents.

The general history of the corn of the Corn Belt has been presented in some detail because it is of more than academic

interest. One of the reasons that hybrid corn has been so successful is because it developed from such a wide and relatively recent mixture of corn, and many of the problems encountered in northern hybrid corn breeding are more closely related to this history than has been generally realized.

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CHAPTER II

IMPORTANCE OF CORN

It is well to understand, in the beginning, that not all the corn acreage in the world was planted in the United States. In Chapter I we read of corn's first appearance as a food and forage plant. From the western hemisphere corn soon moved across all barriers to travel and appeared in all parts of the world, even where climate permits only limited corn production for food. Chapter XXIII discusses these areas in more detail, and Table 28 in Chapter XXVIII lists many countries, other than the United States, where corn is grown. Population and corn production are not equally distributed over the world.

TABLE 1

POPULATION AND CORN PRODUCTION, UNITED STATES AND WORLD

Estimated U. S. population, January 1946	140,386,509
Estimated world population, January 1946	2,150,959,919
Corn production in the U. S., 1946	3,286,927,000 bu
Corn production in the world, 1945 (estimated)	5,010,000,000 bu
Bushels of corn per person in the U. S.	23.
Bushels of corn per person in the world	2.35

Value in the United States. The value of corn in the agricultural United States has been well emphasized by its acreage and its increased number of uses. In recent years the acreage devoted to corn in this country has been decidedly greater than that devoted to any other cultivated crop. In 1944 its dollar value exceeded the combined values of wheat, barley, rye, grain, sorghums, and cotton. There has been an

increasing number of manufactured commodities with part or all of their ingredients derived from corn or the corn plant. (See list on pages 361–374.)

Corn Belt defined. The Production and Marketing Administration of the U. S. Department of Agriculture defines the commercial corn area of the United States as follows:

> Commercial corn producing area shall include all counties in which the average production of corn (excluding corn used as silage), during the ten calendar years immediately preceding the calendar year for which such area is determined (after adjustment for abnormal weather conditions) is 450 bushels or more per farm and four bushels or more for each acre of farm land in the county.

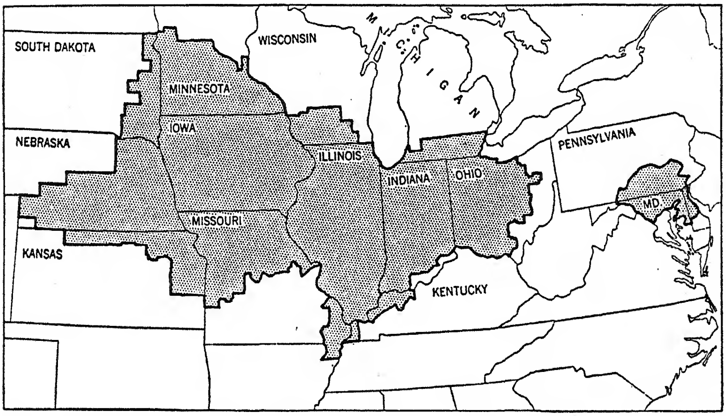

FIG. 3. The United States Corn Belt. Corn is the basis of the wealth of this great agricultural region. Each farm in this region produces on the average at least 450 bushels of corn. Each county included produces four bushels or more of corn for each acre of farm land.

The term Corn Belt, as used in this book, refers to the area defined above.

It will be noted by the above definition that:

1. The area is not constant. It shifts with continued weather conditions that are favorable or unfavorable to the

growing of corn in various areas within or adjacent to the perimeter of the Corn Belt as described above and shown on the map.

2. It also increases in size if and when the Corn Belt is moved farther north, south, and west by the development of adapted strains of hybrids for that area. The same may be true of the development of hybrid strains suitable for other areas in the United States.

3. The size may also be increased or decreased if competing crops prove more profitable over a period of years than corn.

4. The perimeter of the Corn Belt as shown on the map will be defined according to the quotations from the Production and Marketing Administration, U. S. Department of Agriculture.

Corn acreage. Corn occupies from 25 to 30 per cent of the crop land harvested in the United States. Any increase in the yield has substantial influence on the total food production in the United States and the world. Hybrid corn has added more to the change in agriculture and its development than any other innovation that has come to agriculture between the years 1929 and 1947. Hybrid corn was produced first on a very small scale in Connecticut in 1921. The average 20 per cent increase in yield per acre is generally recognized as an increase due to the use of hybrid corn.

The corn acreage and production of corn as compared with other crops in the United States is shown in Table 2.

Wheat, oats, soybeans, and hay crops are grown chiefly as rotation crops which are followed by more corn crops. These crops also use farm labor at seasons of the year when it cannot be readily employed growing corn. Except in parts of Illinois and the northwest section of Iowa, the great part of the corn goes to market in the form of livestock and livestock products. (See Fig. 52, page 300.)

With the introduction of the tractor on rubber tires, the horse has been disappearing from the Corn Belt. Previously

one man could care for about 40 acres before the coming of the tractor. Now one man can plant and cultivate from 120 to 160 acres of corn.

TABLE 2

CROP PRODUCTION—UNITED STATES *

	Corn	Wheat	Oats	Cotton	Hay
Acreage harvested					
1935–44 (average)	91,698,000	55,404,000	36,711,000	24,890,000	70,431,000
1945	88,079,000	65,120,000	41,933,000	17,059,000	77,017,000
1946	88,718,000	67,201,000	43,648,000	17,639,000	72,352,000
Production (bushels)					
1935–44 (average)	2,608,499,000	843,692,000	1,129,441,000	12,553,000 †	
1945	2,880,933,000	1,108,224,000	1,535,676,000	9,015,000 †	
1946	3,287,927,000	1,155,715,000	1,509,867,000	8,482,000 †	
Production (tons)					
1935–44 (average)	72,037,972	25,310,760	18,071,056	2,138,000	91,306,000
1945	80,666,124	33,246,720	24,570,816	2,254,000	108,539,000
1946	92,061,956	34,671,450	24,157,872	2,121,000	100,860,000

* The quantity of production in this table is shown in the usual units of acreage harvested and the productions in bushels for corn, wheat, and oats; bales for cotton; tons for hay. The same figures are translated into tons of corn, oats, wheat, and cotton, and are compared with the tons of hay. This is done because wheat at 60 pounds per bushel, corn at 56 pounds per bushel, oats at 32 pounds per bushel, and cotton at 500 pounds per bale may give an erroneous impression as to their production compared to other crops.

† Bales.

The Corn Belt of the United States is the largest area in the world that is favored with fertile land, rainfall of 10 to 14 inches following planting, and a mean average temperature around tasseling time of 70 to 80 degrees Fahrenheit. The only close competitor is the north central province of Argentina, and in this portion of Argentina winter wheat and alfalfa are profitable. Devastating droughts appear there rather often so that corn is not always successful.

Consumption and uses. The United States had, as of 1946, a corn production of 23 bushels per capita. This amount is disposed of in the ways described in the text and in Chapter XXVIII. We arrive at approximately 10 ears per capita daily of corn, which is used commercially or for livestock or animal food. This, of course, includes all uses of corn from the production of penicillin on the one hand to the production

of liquor and lard on the other. The per capita consumption of corn eaten as human food is approximately 65 pounds annually.

Corn has appeared in the great range regions of the United States in a new role. It has appeared as a wind erosion control crop, or perhaps it may be called a soil conservation crop on land that is being summer fallowed in preparation for a succeeding wheat crop. In the great spring-wheat area of North and South Dakota and Montana, there is an increasing use of corn to help control the wind that blows the soil in the summer. These same cornstalks prevent the wind from removing the snow from the fields, and the moisture is available in the spring for the spring-wheat seeding. Much of the corn planted for soil conservation in this area is flint.

A similar practice has developed in the western wheat area of Kansas, Colorado, Texas, and Oklahoma. This has been possible because of the development of farm machinery that can cover many acres in a day. Here again corn has emphasized its importance outside the Corn Belt proper. This corn in the summer fallow land area is harvested to a very large extent with cattle, sheep, and hogs. Note in Table 3 the column that is headed "Hogging Down, Grazing, and Forage Acreage," compared with the total area of corn grown in any of these great plains states.

The U. S. Department of Agriculture, in the Agricultural Adjustment Act of 1938, made provision for the establishment of four regional research laboratories. These laboratories were built particularly for research on the scientific, chemical, and technical uses for farm commodities and for the by-products resulting from the manufacture of foods from farm products. One of these laboratories is located at Peoria, Illinois, and is known as the Northern Regional Research Laboratory. Corn is one of the subjects of intensive research carried on at this laboratory.

Corn helps the midwestern states to produce a surplus of pork, beef, dairy products, and poultry and eggs. The good

TABLE 3

Crop Utilization, 1947

State	For Grain: Acreage Harvested	For Grain: Yield per Acre	For Grain: Production	For Silage: Acreage Harvested	For Silage: Yield per Acre	For Silage: Production	Hogging Down, Grazing, and Forage Acreage
	thousand acres	*bushels*	*thousand bushels*	*thousand acres*	*tons*	*thousand tons*	*thousand acres*
Me.	2	40.0	80	7	11.0	77	1
N. H.	2	44.0	88	9	11.5	104	1
Vt.	2	40.0	80	44	9.5	418	2
Mass.	6	46.0	276	29	11.5	334	2
R. I.	1	44.0	44	6	9.5	57	1
Conn.	9	48.0	432	37	11.5	426	2
N. Y.	132	34.5	4,554	432	8.4	3,629	58
N. J.	122	43.0	5,246	52	9.0	468	6
Pa.	1,082	42.5	45,985	250	8.5	2,125	20
Ohio	3,098	41.0	127,018	183	7.5	1,372	105
Ind.	4,303	43.0	185,029	89	7.0	623	53
Ill.	8,296	39.5	327,692	209	7.4	1,547	191
Mich.	1,140	28.5	32,490	289	6.1	1,763	177
Wis.	1,285	44.5	57,182	1,185	8.1	9,598	50
Minn.	4,187	38.0	159,106	680	7.2	4,896	367
Iowa	9,547	32.5	310,278	280	6.4	1,792	528
Mo.	3,777	25.0	94,425	80	5.0	400	161
N. Dak.	523	21.0	10,983	143	3.8	543	523
S. Dak.	3,454	20.0	69,080	63	5.4	340	453
Neb.	6,973	20.0	139,460	73	3.8	277	294
Kan.	1,986	18.0	35,748	155	3.7	574	238
Del.	136	32.5	4,420	3	9.0	27	1
Md.	419	36.0	15,084	33	9.5	314	4
Va.	1,054	38.0	40,052	47	10.0	470	29
W. Va.	295	41.0	12,095	8	10.0	80	3
N. C.	2,080	30.5	63,440	15	9.2	138	43
S. C.	1,365	20.0	27,300	4	5.5	22	35
Ga.	2,939	15.0	44,085	10	5.0	50	256
Fla.	546	12.5	6,825	6	5.5	33	139
Ky.	2,136	35.0	74,760	15	10.0	150	28
Tenn.	2,123	29.0	61,567	18	7.0	126	48
Ala.	2,670	15.5	41,385	8	5.0	40	86
Miss.	2,211	16.5	36,482	5	6.0	30	38
Ark.	1,267	17.0	21,539	2	4.4	9	56
La.	941	14.5	13,644	2	4.0	8	17
Okla.	1,221	18.0	21,978	8	4.0	32	43
Tex.	2,877	16.5	47,470	15	3.2	48	53
Mont.	15	22.0	308	7	4.5	32	145
Idaho	16	45.0	720	7	10.5	74	2
Wyo.	26	20.5	533	4	6.5	26	35
Colo.	474	22.0	10,428	64	7.5	280	70
N. Mex.	120	14.5	1,740	4	4.5	18	17
Ariz.	24	11.5	276	3	7.0	21	5
Utah	3	38.0	114	15	9.5	142	7
Nev.	1	32.0	32	1	9.5	10	.....
Wash.	6	54.0	324	6	11.5	69	3
Oreg.	12	42.0	504	10	10.0	100	5
Calif.	27	35.0	945	25	10.0	250	10
U. S.	74,930	28.7	2,153,326	4,640	7.36	34,162	4,411

homes and high land values and the prosperity of the Corn Belt farmer, and Corn Belt towns and cities are the direct outcome of the wealth that corn brings to this region. A field of corn in the Corn Belt produces more useful pounds of material per man-hour, per acre, than can be produced by any other cultivated crop. The corn crop of the Corn Belt has been and will continue to be a bulwark against famine. It is one of the world's great sources of carbohydrates and is proportionately even more essential to an industrialized country than to a primitive society. In times of need, this crop has been diverted from its ordinary uses to be used as human food. During the spring, summer, and fall, the Corn Belt farmer spends about half his time and half the time of his tractor or horses on the production of corn.

TABLE 4

Number of Cars of Grain Sorghums Graded by Licensed Inspectors, United States, 1935–1946

1935	6,361	1941	16,055
1936	4,238	1942	23,149
1937	5,292	1943	40,703
1938	3,088	1944	94,410
1939	2,491	1945	38,142
1940	3,875	1946	55,236

Although industrial uses of corn result in a great variety of products, its greatest importance is as sugars, starches, and sirups for the baking and candy industries.

About 40 per cent of the entire corn production is fed to hogs. Cattle consume approximately 21 per cent, a little more than half of this amount being consumed by dairy cows. Poultry consumes about 13 per cent; horses and mules about 5 per cent; sheep about one-half of 1 per cent. With the exception of horses and mules this is all indirect food production. Corn is really the basis for the wealth of the great agricultural region known as the Corn Belt. (See Fig. 52, page 300.)

Grain sorghums. The grain sorghums have increased tremendously in the total number of cars graded by licensed in-

spectors beginning with 1935 and including 1944, as will be noted in Table 4. The increase has been gradual with about 100 per cent increase from 1942 to 1943 and an even greater increase between 1943 and 1944.

It may be assumed that, with the greater improvement in the ability of grain sorghums to produce high yields per acre and with improved harvesting machinery, the grain sorghums will compete with corn in certain portions of the dry land areas in the United States. Generally speaking, it may be assumed that the feeding value of grain sorghums is approximately 90 per cent of an equal amount of shelled corn.

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CHAPTER III

CORN BREEDING

Prehistoric. Corn has had a long history of selection and improvement. The American Indians differed greatly in their agricultural and horticultural ability. Some of them took little pains in selecting their seed corn; others were more particular and produced uniform, highly selected varieties. Most of them viewed their corn in a religious as well as a practical light; seed selection and planting were connected with special ceremonies. In selecting seed ears, those with even a single off-type kernel were rejected. Among the Six Nations the varieties used in religious ceremonies were increased every four or five years in an isolated plot under careful supervision, furnishing the seed stock from which a supply for religious purposes was raised each year.

Colonial and post-Colonial. When the country was first colonized, eight- and ten-rowed corns were widely grown in the eastern states. Soft white dents and Caribbean flints were known only in the south. At a surprisingly early date it was found that mixtures of flints and softer-textured corns were superior to the parental types. As early as 1835 an article in the New Harmony *Disseminator* described the advantageous results of such crosses and gave detailed directions for the interplanting of two varieties and the detasseling of the female parent. As the middle west was settled and corn became the great American crop, the southern dents and northern flints were crossed and recrossed as has been described in detail in Chapter I. New varieties of dent corn adapted to the northern season were developed from flint-dent crosses, and though for a while the original eight-rowed flints lingered on

in the central Corn Belt they became of progressively lesser importance. As corn gained in importance in the middle west, increasing attention was paid to the shape of the ear and its kernels. There came to be fairly general agreement about what an ear of corn should look like, and thousands of farmers endeavored to produce this ideal out of the flint-dent mixture. Gradually a fairly definite type took shape, varying somewhat with the preferences of the region and of the individual farmer.

CORN SHOW AND ITS INFLUENCE

With the development of state and national shows, opinions became incorporated in show points for judging corn and for a time corn shows had a great influence on the development of corn in the United States. Corn shows first really became popular about 1890 and reached their crest about 1910. In early shows, the idea was to give the prize to the sample which gave indications of the greatest yielding power. As time went on fancy points (particularly with regard to uniformity of each sample) became more and more important. In the central Corn Belt the ideal ear came to be 10½ inches long, 7½ inches in circumference, with twenty or twenty-two straight rows of kernels carried out to the tip, and with a well-rounded butt. The kernels had to be moderately wide, keystone in shape, deep, plump at the tip, and without any trace of being shrunken or blistered. In Iowa and Illinois the judges laid great emphasis on the backs of the kernels being horny and shiny, but in Indiana they were not so particular about this point. In the ten-ear and bushel classes it was necessary to pay great attention to uniformity. All the ears needed to be within an inch of the same length. None could carry fewer than eighteen rows or more than twenty-two. The kernels had to be all the same size, shape, and color and of what the judges recognized as being the "type of variety." To fulfil all these requirements a man had to start with seed from a recognized

strain, grow it on rich soil, and then go over 10,000 or more ears in the hope of finding a prize-winning sample. In the days of the great corn shows, such effort, if successful, always paid off in prestige and usually in dollars and cents. Interest in the shows was nation-wide and extended beyond the borders of the actual Corn Belt. Large premiums were paid to prize winners and the judging of ears of corn became a highly specialized avocation and even a profession. A farmer whose corn placed well in a national show could sell his best ears at a fantastic price and would have been able to do so even though they produced fields inferior in yield. Those few independent men who developed high-yielding "utility" types found very little market for their varieties as seed corn and some of them were subjected to actual derision.

Tests upset ideals. The first corn shows were held before the days of careful experimental work. It is not surprising, therefore, to find that actual yield tests with different types of corn rudely upset some of the most cherished ideals of the early corn judges. For ten years the Ohio station continuously selected for moderately long and moderately short ears of corn and contrasted the yielding power of the two strains. The short ears, only 6 or 7 inches in length, seemed to have the ability to yield almost as much as the ears 9 or 10 inches long. Bare-tipped ears with nearly an inch of cob showing yielded about the amount of shelled corn per acre as ears with perfectly filled tips. Ears shelling out only 76 per cent yielded considerably more ear corn per acre and fully as much shelled corn as ears shelling out 88 per cent. Smooth corn slightly out-yielded the rough corn. Carefully conducted tests of this sort at the Ohio, Nebraska, and a number of other stations made it appear extremely doubtful if many of the points on the old-fashioned corn score card were worth while from the standpoint of yield.

Influence of yield tests. Such experimental results as these began to be recognized by thoughtful farmers and led to the development of carefully planned yield tests. The first of

these conducted on a really scientific basis was the Woodford County, Illinois, test, which was begun in 1919 and completed in 1921. Seed from 120 Woodford County farmers was entered in this test in each of three years. These 120 sorts were grown side by side in two different places in the county. Every other row across the field was a check sort not entered in the contest. By adjusting the yield of entries according to that of the adjoining check, it was possible to take soil variations into account. The Krug strain of Reid Yellow Dent, which stood at the top as an average of the three years, outyielded the average corn in the contest by 6.6 bushels per acre and the poorest, which was also a strain of Reid, by 17.1 bushels. The ten high yielders were grown again side by side in a number of different places in Woodford County in 1922, and again the Krug strain outyielded the others. The result of this test ultimately led to much interest in the Krug strain, and it was widely planted in spite of the fact that it was not a "show type" of corn.

The first state-wide corn-yield test was begun in 1920 by the Iowa Corn Growers Association, following preliminary studies in the two previous years. The state was divided into twelve districts with a testing station in each district. Similar yield tests were soon established in other states, and although their character was greatly changed by the advent of hybrid corn they had a tremendous effect on the kind of corn grown in the Corn Belt. For example, Clyde Black of central Iowa by an ingenious breeding plan had developed a high-yielding strain of dent corn. Before the advent of the Iowa yield test, his corn had never been sought for seed, since it was not of a show type and was variable in color. After the corn placed high in the yield test, he sold so much of it at fancy prices that he eventually went into the seed business.

The development of hybrid corn on a commercial scale has overshadowed the accomplishments of the yield tests, but their role should not be forgotten. They brought to light and gave wide dissemination to strains of high yielding ability. In terms of the actual production of high-yielding gene combinations,

they may have done more for the improvement of Corn Belt corn than has since been accomplished by the inbred-hybrid program.

MASS SELECTION AND EAR-TO-ROW SELECTION

All the early work on corn improvement was based on mass selection. Desirable ears were picked from the corn crib or from the field and seed from them produced next year's crop. Since corn is cross-pollinated this meant that only the female side was being selected. As early as the 1870's W. J. Beal of Michigan was talking to farmer organizations about the importance of the pollen (male) parent as well as the silk (female) parent. He was making experiments with controlled crosses. In the late 1890's the Illinois Experiment Station pioneered in the introduction of what looked like an excellent idea, ear-to-row selection. Seed from individual ears was shelled separately, and part of it was planted in separate rows to make up a breeding plot. Each row was scored for desirable characteristics and for yield. The remnant seed from the ears which produced the best rows was planted the next year and further selections were made from this. In one variation or another the idea was very widely copied, particularly at experiment stations in the Corn Belt. It was soon demonstrated that plant characteristics could be readily affected by this method. In classical experiments the Illinois Station selected different strains, high in oil content and low in oil content, high in protein and low in protein, low-eared plants and high-eared plants. They succeeded in producing strains of corn which were very extreme for each of these characters. By similar process other characters were emphasized. As the result of these demonstrations, there has always been a hope that commercial varieties high in protein may some day be put on the market. It may also be possible to improve the kinds of proteins as well as the amounts.

Yield, however, was another matter. In spite of the most

careful efforts, yield either actually decreased or was not made significantly higher by this laborious method.

DEVELOPMENT OF HYBRID CORN

Meanwhile corn breeding was taking a new direction, though few of the prominent corn breeders of the time aided in the attempt and many of them ridiculed it. Two men, working quite independently of each other, began careful investigations of what happened when corn is inbred. All corn at that time was open-pollinated, as we use the term now. Open-pollinated applied to corn has two meanings. First, it is a term applied to all corn that was grown before there was any production of hybrid corn. Second, the term now sometimes refers to experimental fields where there is no control of the distribution of pollen from or to any of the plants within the field. Dr. George H. Shull and, a little later, Dr. E. M. East demonstrated the precise way in which corn loses its vigor as it becomes progressively more uniform with successive generations of self-pollination. They found, however, that this loss of vigor could be regained by crossing the inbred lines. A completely new method of breeding corn had been achieved. The notorious variability of the open-pollinated corn field was reduced to a large number of inbred lines, each with its own peculiarities, but each relatively uniform. Vigor was restored, or even enhanced, by crossing those lines which yielded best in combination with one another. The first generation of the cross, like most first-generation crosses, was as uniform as the uniform parents. However, the cross could not produce uniform plants and ears the second year. The cross had to be created new each year from the inbreds, in order to maintain vigor and uniformity.

East and Shull started their work in the early 1900's. Although it created tremendous interest because of its theoretical implications, it was slow in being carried into a practical reality. Dr. Shull turned his efforts to an even more theoreti-

cal field, which gave promise of potential importance in practical breeding problems. He studied in great detail the genetics of evening primroses (family Onagraceae). Dr. East and his students, H. K. Hayes and D. F. Jones, continued to explore the possibilities of the new method. In a remarkable

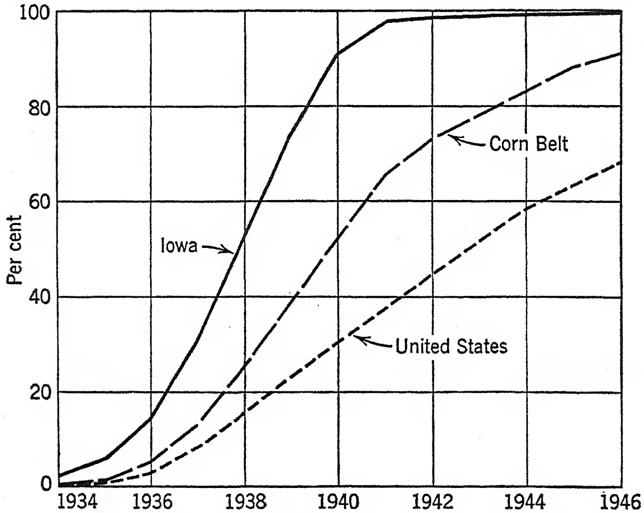

FIG. 4. This chart shows the rapid increase in the planting of hybrid seed corn. Iowa reached 100 per cent promptly. The percentage of hybrid corn planted in the Corn Belt is intermediate between that of Iowa and the entire United States.

experiment they demonstrated that the selection results achieved at Illinois could be arrived at more quickly and more certainly by working with inbred material. Hybrid corn was not commercially practical until D. F. Jones suggested the use of the double-cross hybrid in 1917. A double cross is more variable than a single cross, but it assures the seed producer a good yield of normal-shaped kernels which will go through an ordinary corn planter and are, therefore, readily salable. By 1919 hybrid seed corn was produced in Connecticut and

planted in small amounts by New England farmers the following spring. Relying in part on inbreds developed at Connecticut, Henry A. Wallace developed the hybrid Copper Cross which was advertised and sold by the Iowa Seed Company in 1924. In 1926 the first seed company for the commercial production of hybrid corn was organized.

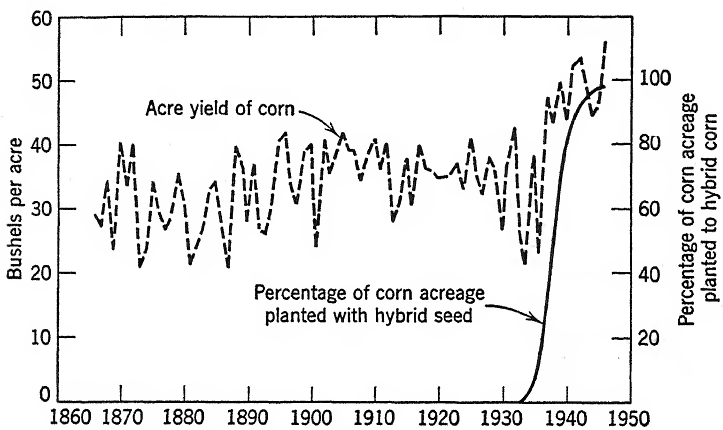

FIG. 5. Percentage of Illinois' corn acreage planted with hybrid seed, and acre yields. Yields during the past 10 years (1937–1946) averaged 46.7 per cent (15.65 bushels) more than during the 70 years (1866–1935) when open-pollinated varieties were grown almost exclusively. (Courtesy Dr. R. W. Jugenheimer.)

The adoption of hybrid corn by the Corn Belt was dramatic when it finally took place. In 1933 only a fraction of 1 per cent of the corn land in the Corn Belt was planted with hybrid seed. Ten years later 78 per cent was hybrid and the curve was still rising. The percentage of hybrid acreage in Iowa reached 95 per cent by 1942 and the other areas followed in successive years.

Hybrid corn yields well, but that is only one factor in its adoption. It has the dependability which comes with hybrid vigor; it produces well on all parts of a field, or in a dry

summer, and it often ripens off more uniformly in the fall. An equally important factor is its uniformity. As more and more of the work on Corn Belt farms is done by machines it becomes more important to have a uniform corn. At harvesting time hybrid corn picks better with mechanical pickers. The uniform appearance of the hybrid fields is also probably a factor. It makes a fine display from the highway, even though it does not accord perfectly with the average farmer's idea of what good corn should look like. As important as any single factor is the great improvement in the way hybrid corn stands up during the harvesting period. Open-pollinated corn, even the best of it, had always lodged badly and was therefore difficult to pick. Particularly in the northern Corn Belt this meant more disagreeable work in the cold, raw weather of late fall and early winter. Hybrid corn comes from inbreds that have been selected for lodging resistance. It stands up well late in the fall. Harvesting is usually completed before high winds and severe storms damage the standing crop.

Development of the hybrid corn industry. The rapid adoption of hybrid corn was a revolution on a scale without precedent in agricultural history. In the ten years from 1933 to 1943 a major agricultural industry came into being, doing a business which grosses in the tens of millions of dollars, employing hundreds of people permanently and thousands of people temporarily, and affecting the lives of most of the people in the Corn Belt. The first companies to go into the business passed from a period when it took almost missionary fervor to persuade farmers to try their product to a full decade during which they could never supply their customers' demands. New hybrid seed companies blossomed overnight, some of them to do business on a nation-wide scale, others to operate only in their own small neighborhood. All of them began in part at least with inbreds obtained from the experiment stations, and some relied exclusively on such material. Some of them began to produce part of their own inbreds on a scale far larger than had been possible in stations de-

pendent on taxes for support, and several of the more aggressive seed corn producers soon initiated research programs on an unprecedented scale.

Best estimates indicate that there are approximately fifty producers of hybrid seed corn who have breeding programs for producing all or part of their inbred strains. The distinction between hybrid seed corn producers who use their own breeding research as foundation for seed production and those who depend entirely on experiment-station single crosses for parent seed is not well defined. Producers of hybrid seed corn within the Corn Belt and adjacent areas number in the hundreds. Some of these produce as little as 500 bushels annually; the bigger producers harvest a million bushels or more annually.

The development of the hybrid corn industry has led to the establishment of numerous breeding plots in which careful variety tests are made, inbreds are compared, new single crosses are produced and tried out, new inbreds are produced, and old ones are improved. The larger companies may have several such breeding plots in different parts of the country, ranging in size from a fraction of an acre to a hundred acres or more.

Planning one of these breeding fields and planting it calls for great attention to detail. Scientific plant breeding is largely an accurate kind of bookkeeping. One must know the ancestry of each plant. This means that all the hundreds of strains and inbreds in a breeding plot must have a name and number, so that one can, if necessary, designate any individual plant or row of plants in the field as readily as one can give the street address of a house in a big city. This attention to detail is necessary because every ear that comes out of a field planted for research and breeding must have a known pedigree that is accurate. If the ear does not have such a pedigree it has very little value in a corn-breeding program. Although various systems may be used, the following plan with some slight modification has become standard practice.

A field is laid out with what are called ranges running in one direction with rows at right angles. With reference to Fig. 6, it will be noticed that the ranges are visible as bare strips of ground across the field. These bare strips of ground are the beginning of a new range, and they are numbered like the

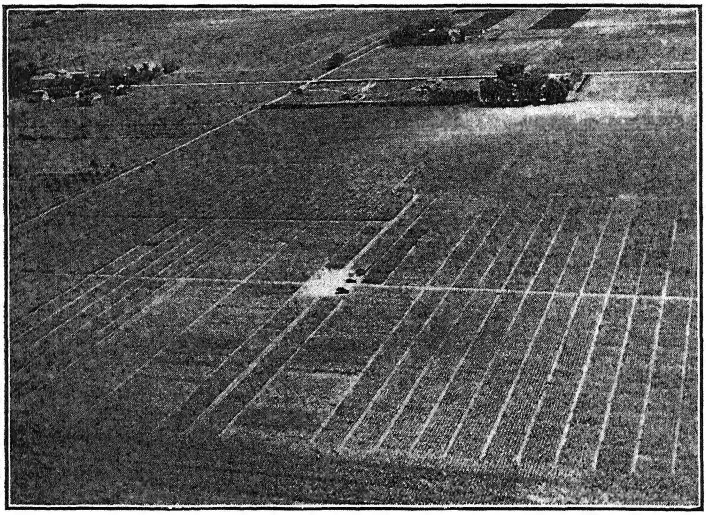

Fig. 6. Corn breeding plots (inbred plot), showing the arrangement of a field for convenient hand pollination. The wide, light-colored strips are bare ground in between the ends of short rows. These bare strips are "range" divisions. The corn rows of twenty to forty hills are planted at right angles to the strips of bare ground.

avenues in a city, from 1 up. The rows of corn are planted at right angles to the ranges, and the row numbers like the ranges continue as far as is convenient for the purpose of the breeding field. The rows may be likened to the streets running at right angles to the avenues on a map of a city.

Hence, a row of corn may be numbered row 43, range 17, which means that one would count, walking at right angles across the ranges, 17 ranges, and then follow the open space between the ranges to row 43. In some fields this row is about

35 feet long. It may be longer or shorter according to the plan.

A map of this field is prepared well in advance of planting time, and the location of the rows and ranges is put on the map. The corn to be planted in any one row that reaches from one range to the next is designated at the time the map is drawn. All these records are put in a field book. At planting time, sufficient kernels are put in a small envelope to plant a row which may be numbered 43. The envelope containing the corn bears the range number and row number. By following this procedure the entire field is planted by hand. One man can plant about two acres per day.

The seed bed is prepared with more than usual care. It is marked north, south, east, and west by a four-row marker, and the corn is planted where the marks cross. In the center part of this field, as will be noticed in Fig. 6, there may be a parking lot, shelters for doing some inside work, and a water supply.

Hybrid corn defined. When the pollen from one inbred strain of corn is applied to the silk tufts of another, fertilization usually takes place. The kernels so produced and the plants grown from such seed are called single cross or F_1. A three-way cross requires a single cross for one parent and an inbred for the other. Both single crosses and three-way crosses are hybrids.

The seed produced from crossing two of the single crosses described above is known as double-cross seed. The term "double cross" is also applied to the corn grown from such seed. Nearly all the big yields and much of the total crop are produced by planting double-cross hybrid seed corn. From this hybrid seed comes the hybrid corn harvested by farmers.

When a supply of single-cross seed is planted in an isolated field where the pollen from this field only is present to fertilize the ovules, the crop is known as F_2 seed. Such seed produces a crop also called F_2.

Seed corn pedigrees. Pedigrees in corn are like pedigrees in livestock. They furnish information about the ancestry of the corn. The combinations of numbers and letters or of name and numbers designate certain inbreds that make up the pedigree.

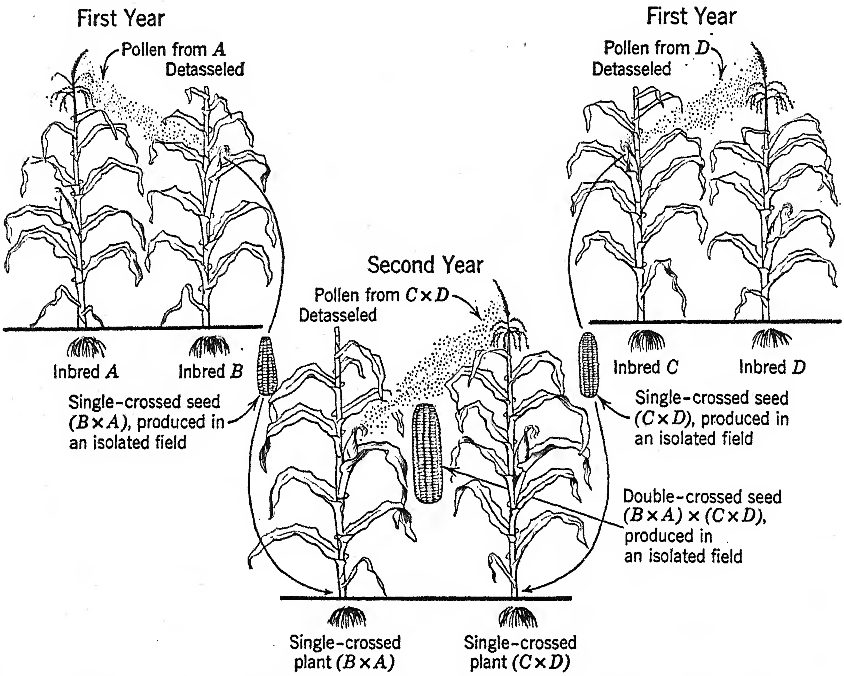

FIG. 7. Read the illustration carefully. The arrow from the double cross $(B \times A) \times (C \times D)$ points to an ear of hybrid seed corn.

The pedigrees may be divided into two classes. Open pedigrees are used rather freely among corn breeders to designate those which are published or available to the general public. The publication furnishes identification of the inbreds that made up the pedigrees and also the information as to where the combination was first developed. Most published or open pedigrees are the result of efforts of state experiment stations

or the U. S. Department of Agriculture. These pedigrees are considered public property since they were developed by public tax-supported institutions.

Closed or unpublished pedigrees apply to combinations of inbreds that have been put together by privately owned organizations in the seed business. The closed pedigree is considered the private property of the individual or firm who created it. The closed or unpublished pedigrees are usually given a number by the private producer. In most cases the number is preceded by a significant part of the name of the individual or group which developed the hybrid. The identification is very likely to have a prefixed name followed by three digits. The name identifies the origin of the seed and the number following the name identifies just what inbreds were used to make this hybrid. That is to say, an identification sign may designate Iowa 939. The seed corn purchaser asks for the corn by number. The number usually means the pedigree.

"Selfing" defined. Self-pollination or "selfing" consists in pollinating the silks of selected plants with pollen from the tassels of the same plants.

Two quite different methods of accomplishing self-pollination are in common use. Both methods require that the young ear shoot be covered to exclude foreign pollen before the silks emerge. Small glassine bags (similar to those used for salted peanuts) are very convenient for this purpose. From this point on the two methods differ widely and will be described separately.

One procedure may be called the "tassel-bagging method." When the silks appear, the glassine bag is removed, the young shoot including a portion of the husks is cut off, and the glassine bag is replaced. The tassel is enclosed in a large weatherproof paper bag at this time. In 24 to 48 hours, an even brush of fresh silks 1½ to 2 inches long will have grown out. The pollen is collected in the tassel bag and dusted on the silks, and the shoot is again covered with the large tassel bag which remains over the ear until harvest.

A second method, usually designated as the "bottle method," was developed by Dr. Merle Jenkins. When the silks appear under the protecting glassine bag, the bag is removed and the shoot is trimmed back as in the previous method. A 2-ounce bottle of water is hung on the stalk at the ear-bearing node. The tassel is cut from the stalk, its shank is inserted in the bottle of water, and tassel and shoot are enclosed in a large paper bag. The tassel should be arranged directly above the ear shoot. The bottle of water keeps the tassel alive while new silks appear, and as fresh silks grow they are pollinated by pollen from the enclosed tassel. It has been found advantageous to use a mild disinfectant in the water to retard the growth of bacteria and moulds and thus lengthen the life of the tassel. A solution of sodium bisulphite 1:2000, which must be fresh, has proved very satisfactory for this purpose.

Inbred defined. In the development of inbred lines, desirable plants of productive varieties are self-pollinated. The resulting ears from the better plants are harvested, the better of these ears are planted, an ear to a row, and the good plants are again selfed. This process is continued for several generations until the lines thus developed breed true for most of the obvious characters. Strains of corn so developed are called inbreds.

Inbreeding in corn always is accompanied by reduction in vigor. It brings to light in the variety any defective germ plasm that has been covered up by the constant crossing which occurs under natural conditions. The reduction in vigor which accompanies inbreeding is greater in the earlier generations of inbreeding and progressively less and less for each generation as inbreeding progresses.

With continued inbreeding there is a marked increase in the uniformity of the plants within lines, although there are large differences between lines. Lines with undesirable characters are discarded, and those of most promise are continued. Experience has shown that, after five to seven generations of inbreeding, uniformity is attained for most plant characteristics.

The development of viable kernels of corn without fertilization by pollen has been investigated by a number of workers.

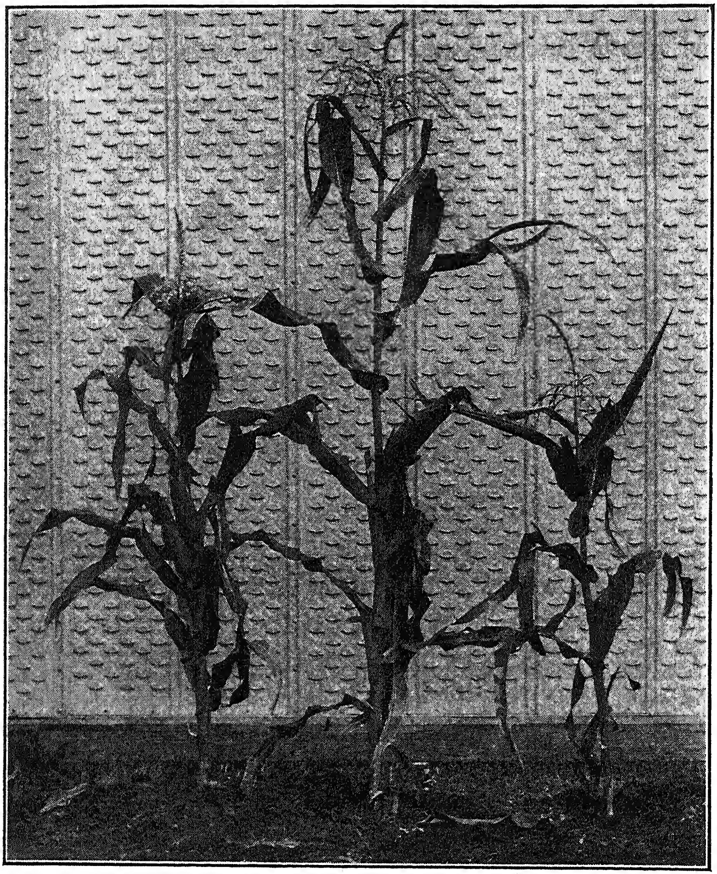

FIG. 8. Two inbreds at the right and left, showing single-cross progeny between them, illustrating the amazing hybrid vigor of F_1.

These kernels are known as haploids; i.e., they have only half the usual number of chromosomes. They tend to appear in some strains of corn at the rate of one-tenth of 1 per cent or

about one kernel per thousand. By using suitable gene markers it is possible to screen large numbers of germinating seeds for haploid plants. By this method the isolation of haploid stocks is relatively simple. Since haploids contain only half the normal chromosome number they are sterile and unable

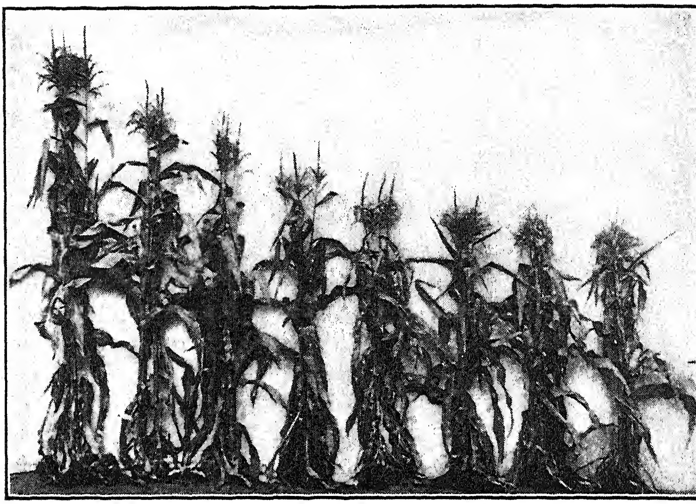

FIG. 9. Continuous reduction in size and vigor due to seven consecutive years of inbreeding of corn. Note that the first four plants indicate a severe reduction in size and vigor, after which the reduction is not very rapid. This early reduction in vigor is expected by most corn breeders in their first three generations of corn breeding. (Courtesy Connecticut Agricultural Experiment Station, New Haven, Connecticut.)

to reproduce themselves. It has been observed, however, that the frequency of spontaneous chromosome doubling in haploids is quite high. This process restores the normal chromosome complement and results in fertile plants. The chromosome number of haploids may also be doubled by artificial stimuli such as colchicine, heat, etc. Although no immediate practical application of haploidy to corn breeding is predicted, haploid plants are of interest to corn breeders in that they

offer a means of studying the behavior of completely homozygous stocks as compared with the performance of relatively homozygous inbreds produced from many generations of self-pollination.

Single cross, top cross, double cross. The first hybrid seed corn to be offered commercially was single cross, that is, first-generation hybrids between two inbred lines. Such hybrids have the advantage of maximum uniformity. Commercially they are undesirable because the seed parent producing the cross is an inbred and, therefore, more or less weak and difficult to grow, as well as having undesirable kernel sizes. The production of single-cross hybrid corn on a scale large enough to produce all the seed corn on the market would be very difficult. Jones, in 1920, suggested the use of double-cross seed for the commercial production of hybrid corn, and his suggestion has been almost universally adopted. In producing double-cross seed, four inbred lines are used, as described in Chapter XIX, and the seed parent of the commercial seed crop is itself a vigorous single cross. Double-cross hybrids have approximately the vigor of the single crosses, but they are less uniform from plant to plant. By a careful selection of inbreds, it is possible to produce double crosses in which the lack of uniformity is of no practical importance. In the days of the hybrid corn business when the demand for hybrid corn exceeded the supply, top crossing was sometimes used. In this case a good open-pollinated variety was pollinated with an inbred line with which it combined well, and the resulting seed was marketed. Some of these top-crossed varieties were very productive. For such areas as parts of Latin America where increases in yield are badly needed but uniformity is of minor importance, the method has a good deal of promise.

Backcross. When F_1 plants are pollinated for one or more generations by one of the original inbreds, the process is called backcrossing. The term backcross has come to include also the selfing of the plants so produced. From these self-pollinated plants those possessing the greatest supply of desirable

characteristics are selected for continued self-pollination and future production of F_1. The process may be repeated in an effort to add other desirable characteristics to the inbred.

Selection of inbreds. In the early days of hybrid corn, it was a simple matter to try various combinations of inbreds and to select for commercial production those which made desirable hybrids. As the number of inbreds increased, this became increasingly difficult and at length impossible. For instance, if all possible combinations of 200 inbreds were tested, 19,900 single crosses would have to be grown and observed. Jenkins and Brunson developed a method of rating the probable usefulness of new inbreds by top crossing them to a standard open-pollinated variety and comparing the yield of the top crosses. They found that with occasional exceptions future usefulness of a new inbred was highly correlated with its behavior in a standard top cross. This method has been widely adopted in preliminary evaluation of inbred lines.

Convergent improvement. The method of convergent improvement developed by Richey and Sprague (see page 50) in their theoretical investigation of hybrid vigor has been of some practical importance in producing better inbreds. With various modifications it has given rise to "second-cycle" and "third-cycle" inbreds. For correcting an obvious fault in an otherwise excellent inbred it has been of considerable value. Although it has been widely used, the results have not been so good as originally had been hoped. Careful and extensive application of this method to particular inbreds has produced second-cycle inbreds in which certain deficiencies were corrected but which gave no significant increase in yield to their hybrids or even slightly decreased the yield.

Combining ability. The truth of the matter is that we are still pretty much in the dark as to why certain inbreds combine well together and others do not. Until we have a more precise understanding of the genetic basis of combining ability, it will not be possible to get the best results from backcrossing.

Early testing. One widely debated development in the pro-

duction of inbreds is early testing as advocated by Jenkins and others. As its name suggests, early testing consists of trying to find out the probable usefulness of a new inbred line at the beginning of the inbreeding period. Data on an extreme development of this method have been reported by Sprague (1946), who points out that its efficiency will depend on the frequency of the genes responsible for the desired qualities. As developed by Sprague, the plants from which the inbreds are to be derived are selfed and at the same time their pollen is applied to a tester parent. These top-cross hybrids are grown the next year, and from their behavior the best 10 to 20 per cent of the original selfs are retained for further inbreeding. After four generations of selfing the resulting inbred lines are tested again. Stadler (1944) has originated a further modification of this technique which he has named "gametic selection." It is of much theoretical interest but has not been extensively tested on a commercial scale.

Recurrent selection. Dr. Fred A. Hull of the Florida Experiment Station has suggested (1945) a plan which includes recurrent selection of corn plants for specific combining ability with a minimum of inbreeding. In breeding by this method a mixture of various kinds of corn is used. The mixture may be seed from double crosses or it may be a composite made by interplanting several promising strains of corn, either open-pollinated or hybrid. This mixture is grown in an isolated plot and allowed to cross pollinate at random. After several such seasons of cross-pollination, a large number of plants are self-pollinated with their own pollen and this same pollen produces hybrid seed with a single cross or some other appropriate "tester." This produces a set of sister crosses, all of which have the same single cross for one parent and some particular plant of the composite strain for the other. In the following year all these crosses are numbered and carefully tested for yield. Since all of them have the same parent on one side, differences in yield (if significant) must be due to differences in the individual plants of the open-pollinated com-

posite. By this laborious method it has been possible to find out which plants of the composite make the best hybrids in combination with the particular single cross which has been used as a tester. The selfed seed of the individuals which produced these superior crosses, and which has meanwhile been held in storage, is planted out again in an isolated plot to form a new composite of "élite" plants. This new mixture is grown again for several generations as an open-pollinated corn crop, and strains are again developed as inbreds. These are again tested in the same way, to locate the plants which make the best hybrids with the "tester."

For the Florida area in which Hull has been working, his plan is perhaps more practical than for the heart of the Corn Belt where suitably isolated plots for open-pollinated corn are very hard to locate and where corn breeders employ many different inbreds of commercial importance; hence the selection of suitable testers would be difficult. However, the Hull plan is of interest from more than one standpoint. The principle of recurrent selection from an open-pollinated composite is, theoretically at least, the answer to a number of problems in corn breeding. If these theoretical possibilities can be supported by concrete data, then it should be possible to work out modifications for adapting recurrent selection methods to Corn Belt conditions.

Male sterile corn. Male sterile corn has always attracted the attention of corn breeders. The attention has been one of curiosity, although the practical implications of this characteristic have not been entirely overlooked. Many of the male sterile factors that have been described are controlled by single recessive genes. To date no method has been devised to use the male sterile plants as females in the production of hybrid seed corn, yet attention is again focused on male sterility in corn plants as a possible opportunity to eliminate the necessity of detasseling for the production of hybrid seed. The fact that corn breeders still maintain interest in male sterility lends encouragement to the belief that perhaps the

hybrid seed corn of the future may be produced without the laborious job of detasseling the female rows.

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CHAPTER IV

CORN GENETICS

As a subject for investigation into the fundamental principles of heredity, the corn plant has few rivals. From the early days of genetics, the science which attempts to discover these principles, corn has been more widely grown and studied by geneticists than has any other plant. Most of this work is so highly theoretical that it is hard to see how it might ever be of any practical importance. Experience, however, has shown that some of it can be of the greatest practical benefit. It was G. H. Shull and E. M. East's purely theoretical inquiries into the effects of inbreeding which laid the foundation for hybrid corn. Collins's careful studies of a strange kind of oriental corn led Jenkins and his collaborators to develop waxy maize (Chapter XVII) as a wartime substitute for tapioca. Corn is a plant of infinite possibilities; no man can ever foresee just which lines of investigation will yield the information for tomorrow's needs. It is fortunate, therefore, that we have so complete an understanding of the genetics of corn.

Heredity in corn. In corn, as in other plants and animals, the hereditary characteristics are carried over from one generation to the next in the male and female germ cells. The male germ cells are in the pollen grains, and the female germ cells are in the unfertilized ovules in the kernels near the base of the corn silks. Each male germ cell or pollen grain contains ten chromosomes, and so does each female germ cell. The chromosomes are the parts of the germ cells which contain the hereditary material. One chromosome may carry the factor which makes the kernels sweet, whereas another in the same

pollen grain may carry the factor which makes the kernels yellow in color.

In the process known technically as fertilization, a pollen grain with its ten chromosomes must fall on the silk of a corn

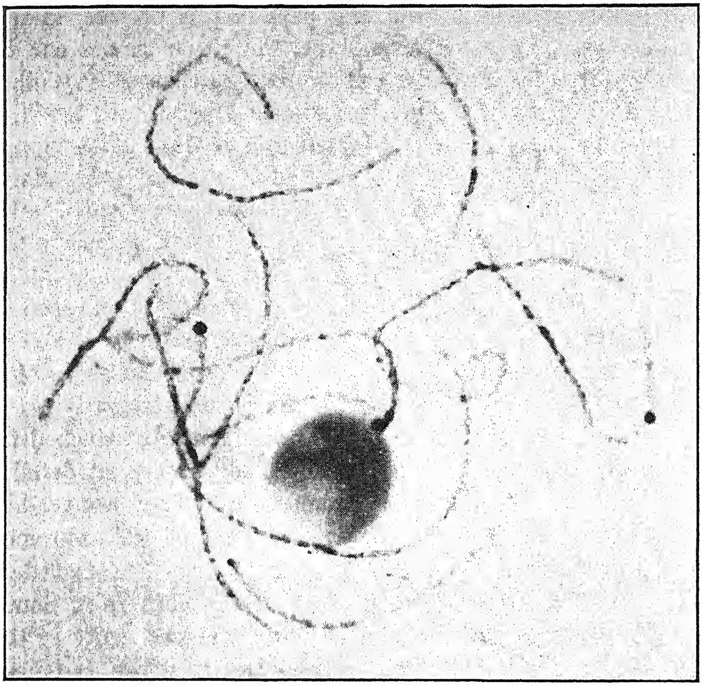

FIG. 10. Photograph taken through a microscope showing nucleus and ten chromosomes in pachytene stage of developing corn pollen. Enlarged about 1500 times. (Courtesy D. T. Morgan.)

plant where it germinates. The pollen tube grows down the silk into the ovule where the ten chromosomes of the pollen grain unite with the ten chromosomes of the ovule. The corn embryo, therefore, and the plant which grows from it, contains twenty chromosomes Shortly before the tassels first appear, if the leaves are stripped down the immature tassel may be

seen, already well differentiated and just beginning to enlarge rapidly. It is at this time in the tassel, and just a little later in the ear, that the cells which are going to give rise to pollen and to ovules undergo a process known as the reduction division, by which the number of chromosomes is reduced from twenty to ten. During the first part of this process, known technically as the pachytene stage, the chromosomes can be more readily studied under the microscope than at any other time. Due to the outstanding studies of Dr. Barbara McClintock we now have more detailed information about the "geography" of corn chromosomes than we have for any other plant. Figure 10 is from a photograph of one preparation made by her methods. It shows all ten chromosome pairs in the pachytene stage.

A. E. Longley of the U. S. Department of Agriculture has shown that strains of corn from different parts of the New World vary in the appearance of their chromosomes as seen under the microscope, most particularly with regard to the number of knobs. These knobs are enlargements attached to, or are a part of, the chromosomes. They appear at definite and specific positions on the chromosomes. They are readily and deeply stained with dyes usually used to stain chromosomes. In their discussion of the origin of corn, Mangelsdorf and Reeves pointed out that much of the corn from South America was knobless, or essentially so, whereas many of the lowland varieties in Central America had as many as ten or twelve knobs for each set of chromosomes. Brown and Anderson presented evidence indicating that the dent corn of the Corn Belt originated from crosses between the northern flints with few knobs and the old southern dents with many. They believe that some day such facts may help to solve some of the problems of practical corn breeding.

Most of the corn kernel is made up of the endosperm, or "nurse embryo." It is that part of the corn kernel which is outside the germ and under the hull. Like the embryo itself,

it is not part of the mother plant and exhibits xenia in crosses between white and yellow corn. The hull is part of the mother plant, and it is impossible for the pollen grain to affect its color.

Xenia. The following is quoted from *Principles of Genetics,* by Edmund W. Sinnott and L. C. Dunn, 1932, page 113.

> From the germinating grain [of pollen] develops a pollen tube which penetrates the style and enters the ovule in the ovary. Down this tube passes the contents of the pollen grain—one non-sexual nucleus and two other nuclei, the true male gametes. One of these gametes unites with the egg cell in the ovule, and from this fertilized egg develops the embryo of the seed. The second male nucleus unites with the endosperm nucleus and gives rise to the endosperm tissue of the seed. This remarkable process of "double fertilization" results in the formation of endosperm tissue, which partakes of both paternal and maternal inheritance; and in plants, where the ovary wall and seed coat are thin and transparent, as in the kernel of maize, a direct effect of the male gamete on the character of the endosperm is evident. Thus, if an ear of maize from a type normally bearing white endosperm is pollinated by pollen from a yellow race (yellow endosperm color being dominant over white), the endosperm of the seeds produced will be yellow. This direct effect of the male gamete on tissues other than embryonic ones is known as xenia.

Red color in corn is usually found in the hull. The hull, like the cob, is not affected by fertilization of the ovule. Ordinary red corn can grow alongside white or yellow corn and no results will be seen that year, but if the white or yellow corn is used for seed the following year, there will be some plants producing red ears.

Just under the hull, as will be noted in Fig. 18, page 77, is the aleurone layer which can also be affected by xenia. The most common xenia effect in the aleurone is a blue color, the heredity of which is complex. Generally speaking, when blue corn pollen fertilizes white or yellow corn ovules, the resulting kernels are blue in color.

Briefly, it may be said that the common xenia effects in corn are with the following pairs of characters, the dominant being named first:

Blue or bluish red color versus no color in the aleurone.
Yellow color versus no color in the horny starch.
Starch corn kernel versus sweet corn kernel.

Red color is never a xenia effect, except a rather rare and dull kind of red which like blue is an aleurone color.

Mendelian characters. Much of the work on heredity in corn has centered around the problem of Mendelian unit factor characters. The number of Mendelian unit characters already discovered in corn runs into the hundreds. Many of them are freaks which so affect the plant that it does not have the capacity of producing an ear which a farmer would save for seed. However, these freaks are found occasionally in fields of open-pollinated corn. One of the commonest freaks has a white stripe running down through the leaves. When a plant of this sort is inbred and the seed is planted, the plants produced all have striped leaves. But if the silks of a striped-leaved plant are fertilized with pollen from a normal plant and the seeds produced are planted, the results will usually be plants all of which appear normal. Such plants carry the striped character in one-half of the pollen grains, and when the pollen of such a plant is used on the silks of the striped plant the result will be plants one-half of which carry striped leaves and one-half of which are normal. Normal plants produced in this way bear pollen one-half of which carry the striped-leaf factor and one-half of which are normal. Also, one-half the ovules or unfertilized corn kernels carry the striped-leaf factor and will produce a striped-leaf plant if striped-leaf pollen falls on their silks. The striped-leaf character is known as a Mendelian recessive, and normal leaf color is the Mendelian dominant.

Following are some of the Mendelian recessives affecting the plant or leaf:

1. Pale green leaf color.
2. Yellow leaf color.
3. Pure white seedlings.
4. Brown midribs.
5. Extremely narrow leaves.
6. Liguleless leaves.

Many such abnormalities are Mendelian recessives. Some of the outstanding exceptions in the way of unusual characters which are Mendelian dominants are:

1. Purple plant color.
2. Brown plant color.
3. Pod corn with a husk covering each kernel.

Heterozygosity and how inbreeding affects it. A plant or animal is said to be homozygous when all its germ cells carry the same hereditary properties. Most corn plants are not homozygous but are heterozygous (germ cells differ from one another). However, there are varying degrees of heterozygosity. For illustration, with reference to ten pairs of characteristics, A versus a, B versus b, C versus c, D versus d, etc., we may say that a completely homozygous corn plant produces germ cells each of which carries the inheritance ABCDEFGHIJ. A slightly heterozygous corn plant might carry half of its germ cells with aBCDEFGHIJ and the other half with ABCDEFGHIJ. Actually, the ordinary corn plant carries dozens of different types of germ cells, as may be roughly illustrated in part as follows: ABCDEfghij, ABcdeFGhij, ABcdEfgHiJ, ABCdefghij, ABcDeFgHiJ, etc. Perhaps a particular plant may have been homozygous for A and B and heterozygous for all other characters. As long as wind pollination continues, there will be little or no change in proportion of homozygosity and heterozygosity. If, however, a plant which is 50 per cent heterozygous is selfed, the next generation will bear germ cells which are much more alike, and the probabilities favor only 25 per cent heterozygosity. In succeeding generations, the heterozygosity should decline to the

following percentages: second, 12.5 per cent; third, 6.25 per cent; fourth, 3.12 per cent; and fifth, 1.56 per cent. After five generations of selfing, it is a general rule that almost complete homozygosity should be reached, provided the plant to start with was 50 per cent homozygous. It takes about seventeen generations of brother and sister mating to give the same degree of homozygosity as five generations of selfing. The "almost complete homozygosity" after five generations of selfing is, however, a theoretical rather than an actual result. Though they are as yet poorly understood, there are various mechanisms in the germ plasm of corn which resist homozygosity so strongly that complete homozygosity may be unobtainable through selfing.

Theory of hybrid vigor. It is theoretically possible but extremely improbable that some day we may find an inbred strain which is homozygous only for good qualities and which would therefore be vigorous. Actually, all inbred strains so far developed by selfing for four or more years are relatively unproductive. When two different homozygous inbreds are crossed, the result is often great vigor. But such result is not inevitable. Some crosses between inbred lines produce hybrids which are little more vigorous than the inbreds. In a few rare cases, the hybrids are actually inferior to their parent lines. The vigor of crosses between inbreds is supposed to be due to the fact that most good characters are Mendelian dominants and most bad ones are Mendelian recessives, and that the first generation cross of two strains gives a chance for all the dominant characters of both parents to appear with none of the recessive, unless the recessives are found in both parents. It is this theoretically sound background which caused so many experimenters to spend much time with corn inbreeding work.

Hybrid vigor had been noticed for over a century by plant breeders and probably for at least 2000 years by animal breeders. Early explanations of the increased vigor of the first generation hybrids assumed that it resulted from the stimulation produced by the mixing of unlike protoplasms from the

egg and the sperm. The reduction in vigor with inbreeding was assumed to be due to the gradual disappearance of this stimulation as the strains became pure or homozygous.

In 1910, Bruce, on the basis of purely mathematical considerations, suggested that hybrid vigor might be explained on the basis of the complementary action of favorable dominant growth factors. F. Keeble and C. Pellew in 1910 reported the results of their experiments with peas, which added considerable evidence to support this explanation. They crossed two strains of peas, each 5 to 6 feet tall. One strain had thick stems with many short internodes and the other thin stems and long internodes but fewer of them. The hybrid was 7 to 8 feet in height. In it the characteristic of thick stems with many internodes from one parent was combined with the characteristic of long internodes from the other. The next generation showed segregation into four classes, one class containing plants as tall as the hybrid, two classes containing plants like the two parents, and the fourth class containing dwarf plants which combined the short internodes of one parent with the thin stems and few internodes of the other.

Two serious objections to the complementary action of favorable dominant genes prevented the general acceptance of this explanation of hybrid vigor. If this explanation were correct, then, according to theory, it should be possible, with inbreeding, to obtain homozygous lines containing the dominant factors contributed by each parent, comparable to the segregates obtained by Keeble and Pellew which had many and long internodes. These lines should be as vigorous as the hybrid and should breed true for their vigor. No such lines of corn have been obtained. Also, as pointed out by Emerson and East, the progeny from crosses exhibiting hybrid vigor should show unsymmterical distributions rather than the apparently normal distributions obtained from them.

The suggestion by Jones in 1917 that linkage between the favorable dominant and unfavorable recessive growth factors would account for the failure to meet these two theoretical requirements removed them as objections to this explanation of hybrid vigor and led to its general acceptance.[1]

[1] *Yearbook of Agriculture,* U. S. Department of Agriculture, 1936, p. 485.

One of the most critical experiments to determine the relative influence of physiological stimulation (see page 38) versus dominant genes in producing hybrid vigor was planned and carried out by F. D. Richey and G. F. Sprague of the U. S. Department of Agriculture. They called their plan "convergent improvement." It consisted in crossing two lines, backcrossing the hybrid to each parent for several generations while selecting for the characteristics of the other parent, selfing to fix the factors held by selection, and crossing the recovered lines in order to concentrate or "converge" the favorable genes from the two parent lines. With successive repetitions of this procedure, within the limits of the effectiveness of selection, there should be a gradual convergence of the favorable dominant genes from the two parental lines into one new strain. With each repetition of the cycle, the recovered strains would be more nearly similar genetically and consequently, hybrids between them less heterozygous. Under the physiological stimulation hypothesis, crosses between recovered lines should be less vigorous than crosses between the original parents. Under the dominant favorable gene hypothesis, crosses between recovered strains should be equal or superior to crosses of the original lines, depending on whether dominance is complete or partial. Since yields of crosses between the recovered lines were consistently high, Richey and Sprague's experiment definitely favored the dominant favorable gene hypothesis. However, as Sprague himself pointed out, such experiments as these cannot by themselves definitely rule out the possibility that physiological stimulation also plays a part.

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CHAPTER V

CLASSIFICATION OF CORN

Corn is a summer annual which belongs to the grass family. Other common farm crops such as wheat, oats, barley, rye, and sorghum belong to the same family. Incorrectly, flax and buckwheat are often called grasses. Botanists classify the corn plant as follows:

Botanical Division	Name	Characteristics
Family	Gramineae	Fibrous root system, leaves alternate, two-ranked, parallel veins in leaves, split leaf sheath, ligule, stems cylindrical with solid nodes, flowers in more or less chaffy spikelets.
Tribe	Tripsaceae (Maydeae)	Male and female flowers in separate spikelets on the same plant.
Genus	*Zea*	Grain borne on a lateral cob, the ripened grains greatly exceeding the glumes.

Besides *Zea* (corn), three other common genera belong to the tribe Tripsaceae: *Euchlaena* (teosinte), *Tripsacum* (gamagrass) and *Coix* (Job's-tears). There are several other genera which are grown in the Orient as primitive forage plants. Job's-tears, which we know only as an ornamental garden plant, has varieties with large, soft-shelled kernels which are an important crop in the Philippines, Burma, Siam, and other tropical eastern countries. In the New World, corn has two relatives, *Tripsacum* (gamagrass) and *Euchlaena* (teosinte). The gamagrasses do not look very much like corn. They are mostly tall, narrow-leaved perennials and are native from the great plains, southward through Mexico and Guatemala, to

the basin of the Amazon. Their inflorescence is bony and jointed. Superficially they show very few characteristics of their relationship to corn, yet Mangelsdorf and Reeves of the Texas Experiment Station succeeded in producing vigorous hybrids between these two different grasses. These hybrids were

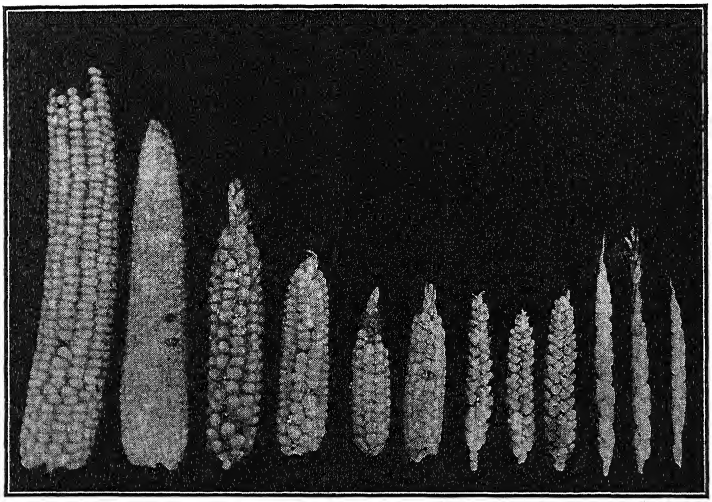

FIG. 11. At the left of the picture is a fairly good ear of corn. At the right is the seed-bearing portion of the teosinte plant. In between the teosinte and the ear of corn are ten stages of segregations. The entire twelve represent the segregations that appear in three or more generations following the crossing of corn with teosinte.

even slightly fertile, and from their studies Mangelsdorf and Reeves eventually concluded that teosinte itself had originated from such a cross, probably long ago in Central America.

Teosinte (*Euchlaena*) is a weedy grass which looks very much like corn, except for its branched ears and small seeds, and it crosses readily with corn when the two grow near each other and flower at the same time. It is usually an annual, like corn, and occurs extensively in certain parts of Guatemala where it has run wild over a wide area. In Mexico it has a

spotty distribution as a weed in corn fields, being very common in a few regions and lacking in others. It crosses so extensively with corn that various collections can be arranged in a series according to their resemblance to the corn plant. At one time it was thought that there were only two or three different types of teosinte. More complete collecting has shown that more are to be recognized and that teosinte, whatever its origin, is even more variable than corn.

Although Mangelsdorf and Reeves' theory has not been accepted by all authorities, it does explain a number of phenomena difficult to account for by any other theory. Mangelsdorf has gone on to demonstrate by precise genetic means exactly where the differences between corn and teosinte are located along the ten chromosomes, and this evidence, when complete, will produce a most convincing argument for his theory.

CLASSIFICATION OF UNITED STATES CORN VARIETIES

Corn (*Zea mays*) is more variable than any other cultivated plant, so variable indeed that some of its major types have not yet been described and only a fraction of its multitudinous varieties has been defined in print. Almost nothing is known about the various types from the Orient, and, aside from Argentina, Mexico, Guatemala, and a few spots in the Andean highland, the varieties of Latin America are still almost unknown to science.

For the United States the main kinds of corn can be effectively grouped according to their kernel texture, as shown in Fig. 12.

1. Dent.
2. Flint.
3. Sweet.
4. Flour.
5. Popcorn.
6. Waxy corn, pod corn, etc.

The six mutant characters listed on page 47 are all true-breeding and theoretically any of these might give rise to a

new kind of corn with special properties. Actually few of them have ever been raised outside experimental gardens, but one can never predict when a use might possibly be found for some of them. Waxy maize has now become useful (Chapter XVII). Pod corn is frequently grown as a curiosity, and some of the striped-leaved and purple-leaved mutants are cultivated as ornamental plants.

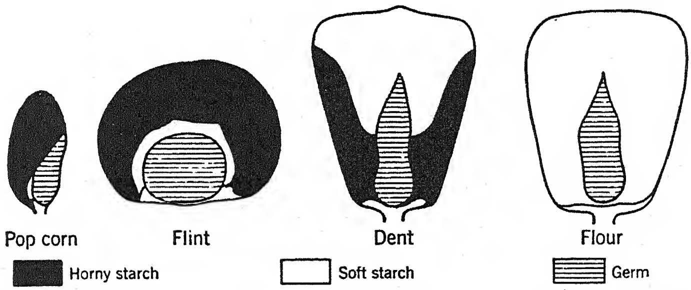

FIG. 12. Diagram from U. S. Department of Agriculture, illustrating differences in kernal texture of different types, ranging from popcorn to flour corn.

DENT CORN

Dent corn is characterized by a depression in the crown of the kernel. This denting is caused by a deposit of soft starch. If there is only a little, it makes a light-colored spot or cap at the crown of the kernel. With a more extensive deposit there is unequal shrinkage between the hard starch at the sides of the kernel and the soft starch which composes the crown. With more and more soft starch the indentation increases all the way from a shallow dimple, to a wide basin or cup, to a deep dent. Fine wrinkles are caused in the pericarp, giving the kernel a rougher appearance. The extreme is found in varieties like gourdseed, in which the whole apex of the kernel collapses, bringing the mature kernel to a kind of withered point.

Dent corn varies in color and in size and shape of ear. There is also a great variation in size and shape of kernel. Some ears of dent corn bear kernels of the extreme shoe-peg type, very narrow and deep. Other ears of dent corn bear kernels of the square type, very wide and shallow. In between are all gradations of kernel type. See Chapter VI for a fuller discussion of dent corn.

Flint Corn

Flint corns differ from dent in that they contain less soft starch and it is more centrally located; therefore, no indentation is formed. Many flints tiller profusely. Though not showy in appearance, flint corns are good yielders and are excellent for fodder.

The flint corns of the United States may be roughly classified in four groups: northeastern flints, plains flints, southwestern flints, and tropical flints.

Northeastern flints. In prehistoric and Colonial times these early-maturing varieties were very widely spread in eastern North America and were relatively uniform. Over large parts of the eastern states all the archaeological material so far discovered belongs to this type. The northeastern flints have wide, crescent-shaped kernels, usually in eight to ten rows, on long ears; they sucker profusely and their husks bear conspicuous blades or "flag leaves." Most of the varieties are either yellow or white. Longfellow flint, King Philip flint, and Smut Nose are outstanding varieties. They are still being grown to a slight extent along the northeastern edge of the Corn Belt, and they produce corn meal of a superior quality.

Plains flints. The flints of the upper Mississippi and Missouri valleys include some northeastern flints, but as a whole the varieties vary more, with higher row numbers and slightly indented kernels being common. As a group they are adapted

to short seasons, high altitudes, and dry conditions. Most of these early flints were developed by the Indians of the northwest with but very little improvement by the white man.

Southwestern flints. Since prehistoric times the Indians of the American southwest have cultivated a remarkable group of drought-resistant varieties, dents, flour corns, and flints. Although they vary greatly in color and size, varieties with long ears and big shanks are common. Flints and semi-flints with barely perceptible dents in some of the kernels are characteristic.

Tropical flints. Tropical flints are not well known in the United States, although they are grown somewhat in Florida and the Gulf states. Yellow varieties called creole flints are very similar to the Caribbean types discussed below. Many of the corn varieties grown in the southern states show evidences of some admixture with tropical flints, and there is historic evidence that the mixture was done deliberately.

Sweet Corn

Sweet corns are characterized by kernels with so much sugar and so little starch that they are wrinkled and translucent when dry. The sweetness is a single recessive characteristic, and Mangelsdorf demonstrated that it was a comparatively simple matter to transfer it to any type of corn. Sweet corns may theoretically be of any general type. Actually those grown in the United States are mostly transformed flint corns (like Golden Bantam). A few, such as Evergreen, are of the dent type. Kelly and Anderson have shown that sweet corns are common in many out-of-the-way places in western Mexico. In the United States sweet varieties are used almost universally for green corn on the cob and canning purposes. This is very rarely done in Latin America. The uses there suggest that they originated in pre-Columbian times and became very widely spread as a source of sugar. (See Chapter XV.)

Flour Corn

Flour corns are grown to only a limited extent in the United States outside the southwest. They are commonly known as "squaw" corn and "flour" corn. Flour corn is usually similar to flint corn in plant and ear characteristics, but it differs in that the kernels are composed largely of soft starch instead of hard starch. Flour corns usually have little or no dent. The horny starch in flour corn is such a very thin shell at the sides of the kernel that it is impossible for any strain of this corn to be deep yellow in color since the yellow color of corn is shown only in the horny starch.

Popcorn

Recent archaeological discoveries have demonstrated that popcorns have been grown in the New World since very early times, and there is a strong possibility that they may have been the first type of corn brought into cultivation. They are of many diverse types and some of them have little in common with each other, aside from their ability to pop. They differ from flints in containing an even higher percentage of hard starch, and their kernels are usually smaller. Popcorn is discussed in Chapter XVI.

CLASSIFICATION OF LATIN AMERICAN CORN

The above classification is wholly inadequate to deal with the various kinds of corn in Latin America, where a single village may sometimes have as many main types of corn as are to be found in the entire United States. Anderson and Cutler outlined the difficulties of classifying corn varieties in 1942 and pointed out that it would be many years before even an approximate classification of Latin American corn could be presented. The following three types, although variable,

are well marked and widespread: Caribbean flint, Mexican pyramidal, and Mexican narrow ear.

Caribbean flint. Caribbean flint corn is one type of tropical flint with chunky, tapering ears, more or less enlarged at the base. The kernels are usually yellow or orange to white. Though seldom dented, there is often a deposit or cap of soft starch at the apex of the kernel. The plants are characteristically large and vigorous. These varieties are widely distributed all around the Caribbean basin, from which they were introduced to Europe and various islands of the Pacific.

Mexican pyramidal. The term, Mexican pyramidal, was coined by Anderson and Cutler to describe the corn type of the central Mexican plateaus. The ears are short and many rowed, tapered sharply and evenly, and the kernels are frequently pointed as well as dented. White is by far the commonest kernel color. The plants are short, wide leaved, and shallow rooted, and the leaves are hairy and are very frequently highly colored.

Mexican narrow ear. The name, Mexican narrow ear, was suggested by Anderson to include various varieties of corn, widespread in western Mexico. The ears are long and taper somewhat to the base as well as to the tip. The plants are tall and deep rooted with slender leaves and wiry tassels.

CLASSIFICATION OF SOUTH AMERICAN CORN

The problem here is even more complicated than in Central America. Hugh C. Cutler has described a few of the extreme types, including the primitive flints and popcorns of the Amazon basin and the highly developed varieties of the Andean regions. Cutler has described a strain of corn known as coroica from Bolivia, South America, which produces ears with odd numbers of rows, nine being the most common.

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CHAPTER VI

DEVELOPMENT AND PARTS OF THE CORN PLANT

The two steps in the development of the corn plant are first, germination, and second, growth. The essentials of these two steps in development are discussed in this chapter.

THE PLANT DEVELOPMENT

Germination. The four conditions necessary for seed to germinate are: (1) vitality, (2) moisture, (3) heat, and (4) oxygen.

Vitality. Under favorable conditions, a very limited amount of corn may retain its vitality for ten years or longer. After the second year of ordinary storage the vigor of germination rapidly declines.

Moisture. Moisture is necessary for seeds to germinate. Water readily penetrates and softens the seed coat of corn.

Heat. Corn is a tropical plant. It requires a higher temperature to germinate than do the small grains. It is a crop which germinates best under higher temperatures than usually prevail in May. The following temperatures are given for the germination of corn: minimum, 42° F; maximum, 111° to 122° F; optimum, 90° F. Cold-resistant strains of corn have been developed which will germinate when the temperature is 42° F, or a little lower.

Oxygen. Oxygen is found in the seed, but not enough for germination. One of the reasons that corn does not germinate well on poorly drained soils is that the excess water in the soil excludes oxygen.

Growth. Growth results from the enlargement of previously formed cells and the production of new ones. During early development general growth takes place, and after the first three weeks of growth all parts of the plant are formed. The six essentials for the growth of the corn plant are: (1) vigor, (2) water, (3) air, (4) light, (5) heat, and (6) plant food.

Vigor. The kernel and the plant that grows out of it must have a vigor that is inherited. A seed may sprout, but if the inherited vigor is not sufficient a normal plant will not develop.

Water. Corn requires large quantities of water to carry plant food and to keep it from wilting. Kiesselbach of Nebraska found that the rapidity of transpiration of corn varies directly with the temperature and the leaf area. A well-grown corn plant on a hot day in late July will transpire 5 to 10 pounds of water. This means that, during July and August when the corn is most active, an acre of corn plants is pumping up water from below and throwing it into the atmosphere at the rate of 18 tons daily, or 720 tons of water per acre, equivalent to 7 inches of rainfall. It has been estimated that 11½ inches of rainfall is required to grow a 60-bushel corn crop under average Iowa conditions.

Air. Air must be present in the soil to a considerable depth to permit the proper release of elements necessary for the growth of the plant. Part of this process is the action of bacteria on the partially decayed vegetable matter incorporated within the soil. Corn roots do not go below the water level in the soil. Air is always present in soil down to the water level. Soils that are particularly deficient in humus have less air than those that have a great quantity of humus.

Light. Light furnishes the power which all green plants require. The process by which green plants take sunlight and store up its power is known as photosynthesis (light-building). In photosynthesis the carbon dioxide of the air enters the leaves through stomata (little holes) and is there combined with water by the power of the sunlight to produce starch and other carbohydrates. Of all green plants, corn is one of the

most efficient in capturing sunlight in large quantities and storing it away in the form of starch. In recent years it has been shown that the length of day has a pronounced effect on the flowering habits of corn plants.

Heat. Corn requires a large amount of heat for development. In a Pennsylvania experiment it was found that, during the twenty-two days preceding tasseling, those days with a mean temperature of less than 70° F usually resulted in a growth of 3 to 3½ inches in twenty-four hours, whereas those days with a mean temperature of 75° F or more resulted in a growth of 5 or 5½ inches in twenty-four hours. When the temperature in the daytime exceeded 85° F, further increases did not seem to result in greater growth, probably because of moisture shortage.

Plant foods. A fifth essential for growth is plant food. Corn requires the following chemical elements: Carbon (C), hydrogen (H), oxygen (O), phosphorus (P), potassium (K), nitrogen (N), sulphur (S), calcium (Ca), iron (Fe), magnesium (Mg). The expression "C. HOPK(i)NS CaFe Mg (mighty good)" is a reminder of the essential chemical elements. There are other elements needed in trace amounts. For a discussion of these see Chapter VIII, Table 7.

Oxygen, carbon, and hydrogen are furnished by air and water, whereas the other elements are minerals in the soil. About 97 per cent of the elements in the corn kernel comes from the air and only 3 per cent from the soil. Each element is a specialist in its own field and cannot be completely replaced by another. This fact is illustrated by the low yield or growth of plants that do not have sufficient nitrogen.

Oxygen is the most abundant element. It readily forms compounds with practically all other elements and constitutes about one-half of all known matter. It enters the plant as carbon dioxide (CO_2), a gas, and water (H_2O). In the plant it is further changed by sunlight to build up the carbohydrates and proteins. The corn kernel is about 46 per cent oxygen.

Carbon is closely associated with plant life. It enters the leaves of the plant in the form of CO_2, where it is combined by sunlight with water brought up from the roots to form sugar, starches, and the like. Carbon composes 45 per cent of the corn kernel.

Hydrogen is the third most abundant element in the corn kernel. It makes up 6.4 per cent of the corn kernel. Water is the one important source of hydrogen for plant growth. This element is combined by sunlight with carbon and oxygen to form the various carbohydrates and proteins within the plant.

Nitrogen is one of the most important and possibly the least appreciated elements. It forms one-sixth of the protein in plants, the formation of which would be stopped without it. About 1.5 per cent of the corn kernel is nitrogen. Nitrogen's functions in the plant are to:

1. Stimulate growth of the entire plant.
2. Impart a deeper green color to the foliage.
3. Delay the maturing process.
4. Control the amount of other plant foods used.

Sulphur is an important constituent of both protein and protoplasm. In most corn soils there is a great abundance of sulphur. About 0.13 per cent of the corn kernel is sulphur.

Phosphorus is found in every cell of every plant, but it is especially abundant in the seed. About 0.26 per cent of the corn kernel is phosphorus. It is of great value because it:

1. Causes rapid germination of the seed and vigorous, early root growth.
2. Causes early ripening.
3. Causes greater formation of the seed in proportion to the stem.
4. Is essential to protoplasm.
5. Aids in proper maturity.

Potassium plays an important role in the development of plant life. About 0.32 per cent of the corn kernel is potassium. It seems to:

1. Encourage carbohydrate formation.
2. Aid in the transference of starch.
3. Aid the plant in resisting fungus disease.
4. Be essential to normal growth.

Calcium is fundamental to both plant and animal nutrition. The corn kernel contains less than 0.1 per cent of calcium. Its functions are to:

1. Aid in the development of root hairs.
2. Aid in the transportation of starch.
3. Neutralize plant acids, which help to release available soil nitrogen.
4. Strengthen the cell walls.

Calcium, phosphorus, and potassium, when found in abundance in the soil, keep the corn plants from absorbing undue amounts of aluminum and iron and thus predisposing themselves to diseased joints, fired leaves, and root rot.

Magnesium is found more particularly in the seed of plants. In this respect, it is the opposite of calcium. Practically all soils contain sufficient magnesium for plant growth. About 0.14 per cent of the corn kernel is magnesium.

Iron is second to oxygen in abundance in the earth's crust. It is never a limiting factor in production, as plants use only a small amount of it. Nevertheless, iron is essential to chlorophyll production. If iron is withheld from plants, no chlorophyll will develop, and consequently the plant makes no natural growth. Only small traces of iron are found in the corn kernel. Iron may act as a poison to corn, especially in tight clay soils which are low in phosphorus, calcium, and available potash. Of these ten essential elements, there are three, phosphorus, potassium, and calcium (lime), which must be purchased and added to some soils in the Corn Belt, if experiment and analyses indicate a need, to keep them producing. Nitrogen may be produced on the farm or purchased in fertilizer form for use on the farm. The other elements are

usually present in abundance already or may be included in fertilizer applications.

ROOTS

Corn, like other grasses, has a fibrous root system. The four types of corn roots are: (1) tap roots, (2) seminal roots, (3) permanent roots, and (4) brace roots.

Tap roots. The tap root system is composed of the tap root which is pushed downward from the tip of the kernel when it first sprouts. A few kinds of corn have no other root for the first several weeks.

Seminal roots. Most of the corn grown in the United States has three to seven small seminal roots which grow out sideways from the kernel, immediately after the development of the tap root. During the first two or three weeks after germination the tap and seminal roots furnish most of the food which the young plants obtain from the soil. Later these roots either rot away from the plant or become unimportant, except in varieties such as Hopi corn, which seem to rely on the tap root to bring up moisture from the deeper layers of the soil. If the young corn plant is dug up two or three weeks after germination, a slender white stem will be noted between the kernel and the green stem above ground. This is known as the mesocotyl. In corn planted 1 inch deep the mesocotyl is usually less than 1 inch long. In deeply planted corn the length of the mesocotyl varies greatly. In varieties from the American southwest and from western Mexico the mesocotyl may be a foot or even more in length if the corn has been planted deeply.

Permanent roots. The first two, three, or even four nodes of the mature corn plant are separated by very short internodes and are just below the surface of the ground. It is from these nodes that the permanent roots start out laterally and then go downward to a depth of as great as 10 feet. The large, strong, permanent roots are concentrated within a foot or two

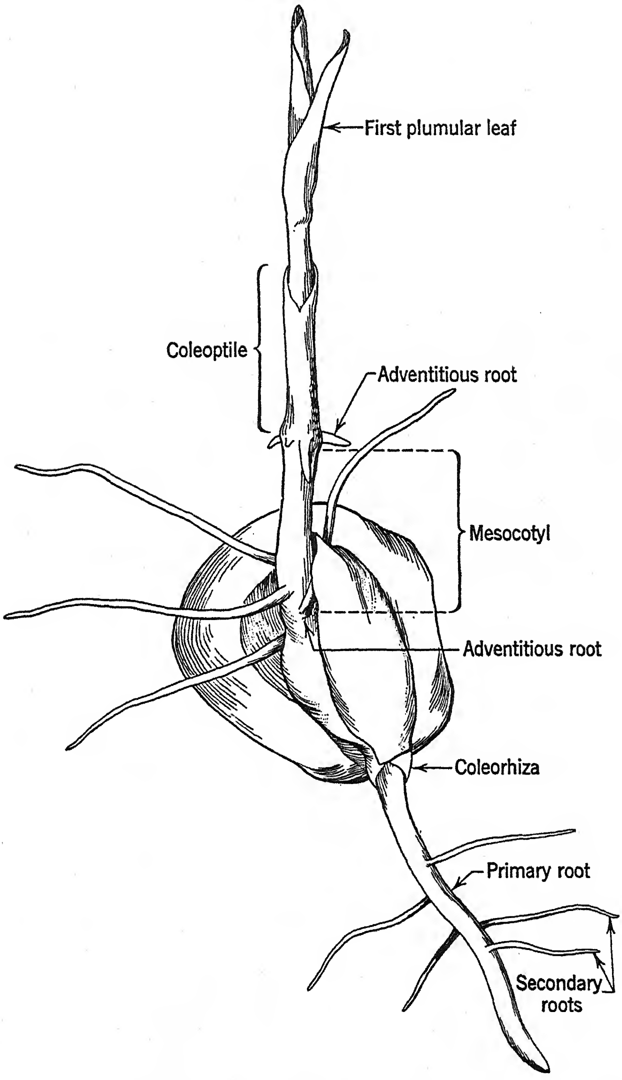

Fig. 13. Drawing showing parts of young seedling corn plant.

of the plant, and only the small, fibrous roots reach the greater depth.

Brace roots. Brace roots differ from the permanent roots in that they come from the first two or three nodes above ground. In corn that has blown down or in certain tropical varieties that have been moved northward, the brace root may come out from nodes as high up as the fifth or sixth node.

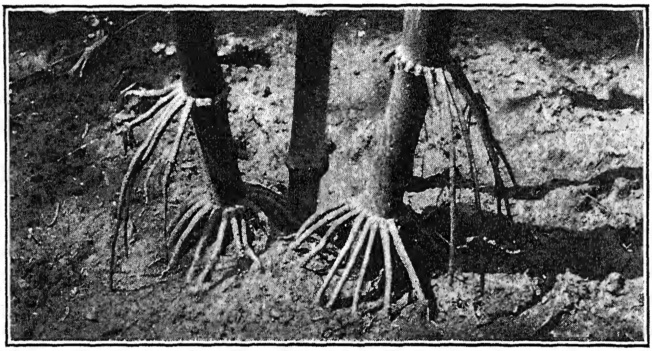

FIG. 14. Brace roots. (Courtesy Iowa Agricultural Experiment Station.)

Brace roots from the first node or two above ground are of very real help in maintaining an upright corn plant, but it is doubtful if brace roots from the higher nodes serve any useful purpose.

The roots of the corn plant:

1. Support and anchor the stalk.
2. Absorb plant food (soluble salts and water).
3. Excrete organic substances (such as carbon dioxide and organic acids).
4. Render plant food soluble by action of the excretions.

Root growth is increased when the following conditions are present:

1. Large supply of oxygen in the soil.
2. Favorable temperature.

3. Plenty of moisture.
4. Good soil tilth.
5. Abundant available plant food.

CORN PLANT ABOVE GROUND

Stalks. The stalks of corn vary in height from 1½ to about 30 feet. Some of the small, early popcorns will develop ears when only 1½ feet high. Corn from Central America moved north often grows to a height of 15 feet or more.

The stalk is made up of nodes or joints, usually eight to twenty in number; the average number is about thirteen for dent corn. The node is the origin of all lateral outgrowths, such as roots, branches, leaves, and ears. The portion of the stalk between the nodes is called the internode. The longest internode is usually the one that bears the tassel, and the shortest one is usually closest to the ground. The longer internodes are found toward the top of the stalk, and the shorter toward the base. The stem of each internode below the ear is indented or hollow on one side, and it is on this indented side that the leaf comes out. On this side of the lower nodes a small bud develops which becomes increasingly important at each successive node. In dent varieties in the United States there is usually a perfect ear at the uppermost indented node, and an imperfect ear or nubbin at the next node below. Theoretically an ear is possible at all the lower nodes, though in most varieties of corn microscopic examination is necessary to demonstrate those at the lowest nodes. The ear is usually borne in the top indentation.

In cross section, the stalk is made up of four main parts:

1. The epidermis, a thin transparent tissue, covers the outer part of the stalk. It is impervious to moisture and protects the stalk from insects and disease.

2. The stem wall is just beneath the epidermis. It is a woody layer, the hard, stiff portion of the stalk, made up of large numbers of fibrovascular bundles, closely packed together. These bundles,

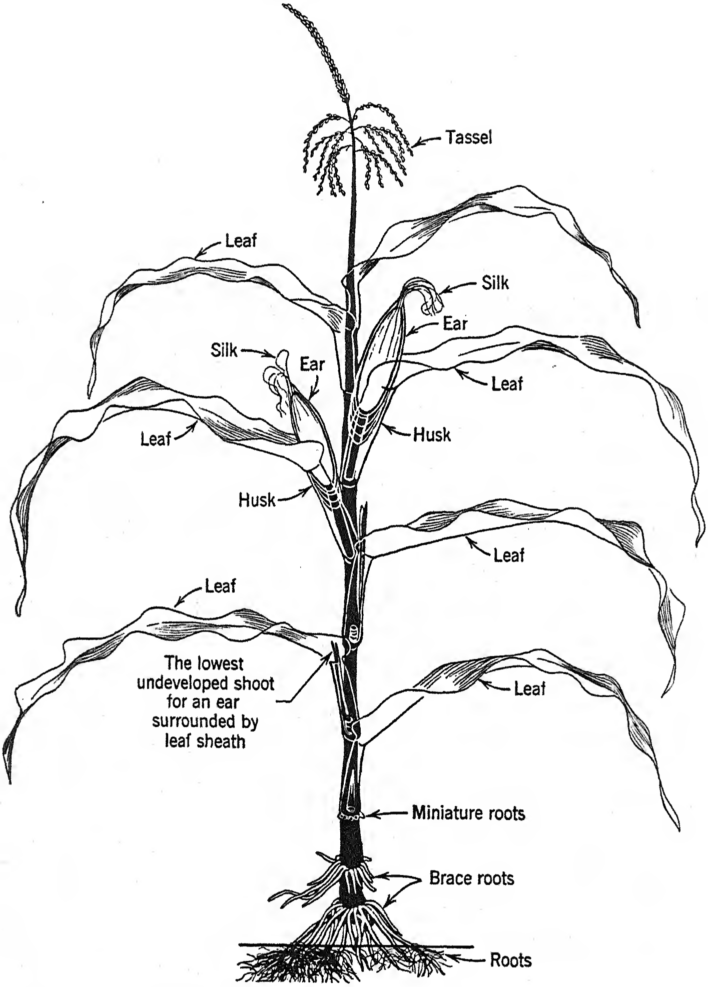

FIG. 15. Skeleton of full-grown corn plant. See section on roots in the text.

stiffened by silica deposits, make the stem wall the "backbone" of the plant. The strength of the stem wall is not the same in all varieties of corn.

3. Pith fills the center cavity of the stalk. It is a soft, spongy mass of tissue and serves as a storehouse for moisture and food. The fibrovascular bundles in the pith are separated by large masses of pith.

4. The fibrovascular bundles are channels for the transportation of plant food. They are found mostly in the woody stem wall and extend from the roots up through the stalk to the leaves and ears. These fibrovascular bundles look like string stretched through the pith from node to node. They also appear in the pith at the butt of the cob. They carry mineral plant food from the roots to the leaves and manufactured plant food to the ears and stalk. A little food is manufactured in the stem as well as in the leaves.

Length growth takes place just above the nodes and within the tassel. The growth may be likened to the action of a telescope. As a telescope unfolds, so does the cornstalk unfold. Therefore, the statement that we can "see corn grow overnight" is often made. Diameter growth takes place from the inside and not by the addition of layers as in a tree. This type of diameter growth is called endogenous growth. "Hearing corn grow" is actually the noise made when the internode slides slowly out of the leaf sheath.

Suckers. Suckers, or tillers, are branches which come from the nodes just at or just beneath the surface of the ground. The tendency for a plant to have suckers is influenced by heredity, length of day, soil condition, and rate and method of planting. A large amount of available plant food, particularly nitrogen, will produce more suckers than will soil in poor condition. Plentiful moisture increases the number of suckers.

Corn planted one kernel to the hill will send out more suckers than corn planted five kernels to the hill. Suckers have their own root system and often bear ears. However, the ears as a rule are inferior to those on the main stalk, often being borne on the tassel. Geneticists have been able

to reduce the number of suckers that appear on corn by careful selection.

Leaves. The leaves on a corn plant are arranged alternately on two sides of the stalk. One leaf appears for each node. There are usually twelve to eighteen leaves. The wavy margin, the result of the outside's growing faster than the midrib, adds surface and flexibility to the leaf. The corn leaf is made up of three parts.

1. The *leaf sheath* comes from the node and clasps or surrounds the stalk, hiding all of it except a short upper portion.
2. The *blade*, often incorrectly called the leaf; is composed of the midrib, the veins (parallel to the midrib), and intracellular tissue.
3. The *ligule*, located at the hinge between the leaf sheath and the blade, is a collar which prevents water, dirt, and insects from running down the sheath and stalk. At either end of the ligule is situated the auricle, or lobelike portion. It is the small light-green, wavy, triangular portion of the blade. It turns the water down the stalk onto the leaf below.

In the leaves and stalks are large numbers of small openings known as stomata, through which carbon dioxide of the air passes into the interior of the leaf. The leaves, by means of their chlorophyll or green coloring matter, are able to use the energy of the sunlight to combine this carbon dioxide with water and ultimately to form sugars and starches. The leaves, besides manufacturing food, serve a useful purpose in evaporating surplus moisture. On a hot July day the leaves of an ordinary corn plant will evaporate from 5 to 10 pounds of water.

Flowers. The male and female flowers of corn are located in spikelets on different parts of the same plant. This flower arrangement makes cross-pollination and fertilization the general rule in corn. It is estimated that not more than 5 per cent of corn grown under field conditions is selfed (pollen falls on the silk and fertilizes the ovule of the same plant).

The male flowers are located in spikelets on the tassel of the plant. Each spikelet contains two flowers, and each flower

has three anthers which contain the golden colored pollen. There are about 2000 pollen grains in each anther, and there are about 7000 anthers in each tassel. Therefore, each tassel may furnish about 14,000,000 pollen grains. This number is far in excess of the pollen required, because only one pollen

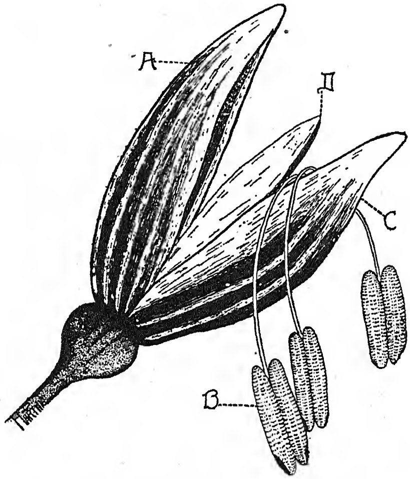

FIG. 16. The staminate or male spikelet as borne by the corn tassel. (*A*) Upper flower, which has not yet opened enough to show anthers. (*B*) Anther of the lower flower. (*C*) Empty glume. (*D*) Palea.

grain is needed for the development of each kernel, and an ear requires only from 800 to 1000 pollen grains to bring about the development of all possible kernels. There may be, therefore, 20,000 or more pollen grains produced for each kernel. The pollen is carried by the wind, and occasionally pollen may be blown half a mile. There is, however, much less mixture between fields than is commonly thought. How long pollen maintains its vitality depends on the temperature. On a hot summer day there is a little viable pollen left at noon from all that was shed during the early hours of the morning. In cool weather, on the other hand, it may retain its vitality for

twenty-four hours. Pollen is very susceptible to drought and particularly to hot dry winds. Under such conditions much of the pollen is destroyed before the anthers open and the remainder shrivels up in an hour or so.

The tassel, in most Corn Belt corn, emerges before the silks, making the pollen available from one to three days before it is needed. The female flowers are located in pairs on the cob. Only one flower of each pair develops, except in such varieties as Country Gentleman sweet corn, in which both develop. An average ear of corn will have about 800 developed female flowers. Each flower sends out a silk (style), and it takes from two to four days to send out all the silks in favorable weather. The kernels about an inch from the butt end of the ear send out their silks first. The end (stigma) as well as the surface of the silk is hairy and mucilaginous, to aid in catching the pollen grains. These silks are receptive to pollen before they emerge from the husk, and if they are not fertilized they may remain receptive for about two weeks.

Fertilization. Kiesselbach says: "Every kernel has its own silk and must be fertilized separately. In the process of fertilization, pollen falling on the silk germinates and grows a pollen tube through the silk to the kernel, to which it conducts the two sperm nuclei. One of these nuclei fuses with the egg nucleus to form the initial embryo nucleus (true fertilization), and the other with the two polar nuclei, forming the initial endosperm nucleus. This endosperm nucleus is called xenia. This process has been found to be completed within approximately twenty-four hours' time. Fertilization is reflected in the discoloration and drying of the silks in from forty-two to seventy-two hours after pollination."

Ear compared with sucker. The ear, including the shank and husks, is in reality a very much shortened branch of the main stalk. The nodes of the shank occasionally bear several small ears in addition to the main ear. Each husk represents the leaf sheath, and the streamer (flag leaves) often found toward the top of the husk is comparable to the leaf blade. The

ear is analogous to the tassel. However, except in freak ears, the cob has no lateral branches.

As a rule, Corn Belt varieties mature only one good ear of corn on each stalk, but they always bear small undeveloped

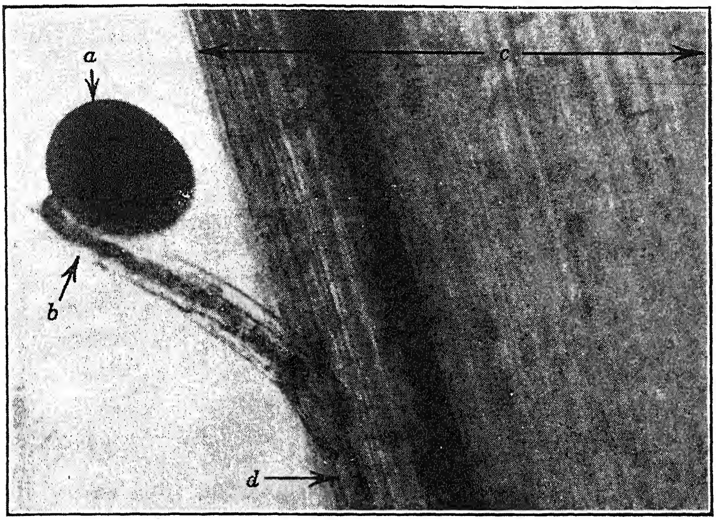

FIG. 17. Pollen grain (*a*) on one of the little fuzzlike projections (*b*) from the side of the corn silk (*c*). The round, egg-shaped portion is a pollen grain starting to grow from the grain to the fuzzlike projection and from there down to the pollen tube (*d*) which reaches to the ovary on the miniature cob. This photograph taken through a microscope and magnified 250 times. (Courtesy Pioneer Hi-Bred Corn Company.)

ears at the lower nodes, though most of these are hidden by the leaf sheaths. Prolific varieties mature several ears on one stalk.

Kernel. In the ordinary season the kernel is ripe about fifty days after fertilization. A shorter time is required for the early short-season hybrids, and more time is required for the late, long-season hybrids. Twenty days after fertilization the kernel is ripe enough to germinate, although it has only reached the milk stage by this time.

The stages of ripening are:

1. Milk stage—starch in the form of a fluid (about twenty days after fertilization).
2. Soft dough—starch soft and cheesy (about thirty-five days after fertilization).
3. Hard dough—starch hard and firm (about forty days after fertilization).
4. Glazed (about forty-five days after fertilization).
5. Ripe (about fifty days after fertilization).

All stages require more or less time, depending on whether the corn is a late or early type.

The kernel may be divided into six parts:

1. Hull—also called pericarp, the thin covering which encloses the entire kernel. The hulls on eighty Corn Belt inbreds were examined. The colors ranged from transparent or almost colorless to graded browns, the extremes being almost opaque. Another group shaded to red and a third group to a distinct yellow.
2. Aleurone layer—a thin layer just beneath the hull. In U. S. dent corns this layer is colorless and difficult to distinguish.
3. Soft starch—loose starch cells that occupy the crown and the whole central portion of the kernel. It is often called white starch. In soft or flour corn, nearly all the kernel except the germ is soft starch.
4. Hard starch—compact starch cells that occupy the sides and back of the kernel. Careful observation indicates that the so-called hard starch and soft starch do not indicate a difference in the starch itself. All the starch is tightly packed into the cells of the kernel. The starch occurs as single grains, and around these grains is a tight protein network. This network can vary in thickness and density. When it is thick and dense and the starch grains fit together closely, the starch in this part of the kernel is referred to as hard starch. When the network is thin and delicate and the grains are not pushed together quite so closely, the starch in this area is called soft starch. Research conducted on the subject of starch has not yet indicated any significant difference between the starch derived from the hard portions of the kernel compared to that derived from the soft por-

tions of the kernel. Hard starch is translucent to the naked eye, whereas soft starch is opaque. In flint corn the soft starch is centrally located and is not apparent without cutting open the kernel. The color of yellow corn is found solely in the hard starch, which means that yellow flint varieties have a far deeper color than either

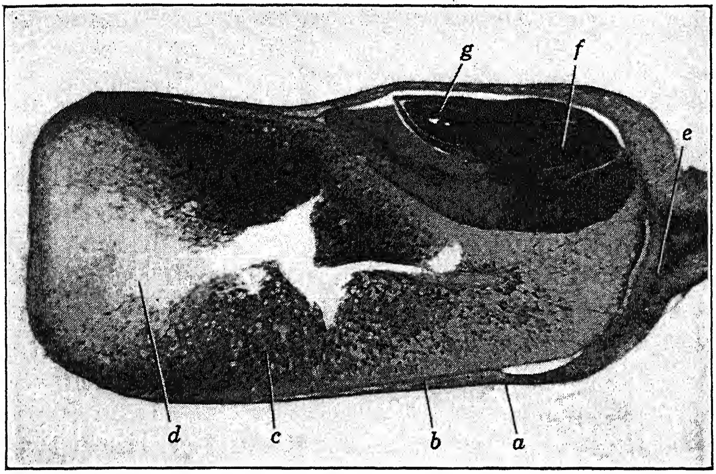

FIG. 18. Longitudinal section of a kernel at approximately dent stage of maturity. The outside thin layer (*a*) is the hull. Immediately inside the hull is a thicker covering, the aleurone layer (*b*). The horny starch is indicated by (*c*), and (*d*) is the soft starch. Just left of the tip is that portion we see (*e*) when the corn is shelled, showing a black tip of corky substance. The remaining portion is the germ proper. Towards the tip end of the kernel is shown the radicle (*f*), and towards the big end of the kernel, enclosed in the miniature leaves, is the growing point (*g*) of the plumule.

the soft or dent varieties. The hard and soft starch and the aleurone layer make up what is commonly called the endosperm.

5. Germ—oily portion occupying most of the front side of the kernel. The germ is composed of three parts: the plumule, the radicle, and the scutellum. The plumule develops into the stem sprout and permanent roots. The radicle develops into the temporary roots. The scutellum absorbs, changes, and transfers plant food for the seedling.

6. Tip cap—affords attachment of the kernel to the cob and protection to the germ. The tip cap is really attached to the hull. The tip cap and the hull are botanically a part of the cob. The tip cap is usually retained by the kernel in shelling. When broken off, it exposes the black covering of the germ. This covering is natural and not an unsoundness.

In dent corn the pericarp, or hull, constitutes about 5.5 per cent of the corn kernel, the tip cap 1 per cent, the endosperm about 82 per cent, and the germ about 11.5 per cent. Of the total mineral matter (ash) in dent corn about 17 per cent is in the endosperm, 80 per cent in the germ, 2 per cent in the hull, and 1 per cent in the tip cap. Of the total protein, about 75 per cent is in the endosperm, 22 per cent in the germ, 2 per cent in the hull, and 1 per cent in the tip cap. Of the total oil, about 15 per cent is in the endosperm, 83.5 per cent in the germ, 1 per cent in the hull, and 0.5 per cent in the tip cap. Of the total sugar, about 26.5 per cent is in the endosperm, 72 per cent in the germ, 1 per cent in the hull, and 0.5 per cent in the tip cap. Of the total starch about 98 per cent is in the endosperm, 1.5 per cent in the germ, and the remaining 0.5 per cent in the hull and tip cap.

The conversion factors compiled from various trade and government sources indicate that a bushel of corn (56 pounds) may yield: 35 pounds of starch or 27.5 pounds of sugar (refined hydrous dextrose) or 40 pounds of sirup, and 1.5 pounds of oil, 12 pounds of gluten feed, and 2 pounds of oil cake.

The starch is on a commercial basis (11–12 per cent moisture), and there is no figure available for dextrin conversion. There has been no differentiation as to the type of oil, but it is probably on a crude basis.

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CHAPTER VII

PREPARATION OF THE SEED BED

In preparing land for corn planting, the main objects are to make it easy to kill weeds and to make it possible to plant the corn at a uniform depth. Ideally, the seed bed should be firm with a mellow, level surface and with the trash cut up finely and well covered. Disking and harrowing after plowing kills many young weeds which otherwise would have to be killed with the corn cultivator after the corn is up.

Corn is planted on ground which has been in corn, in small grain (stubble ground), or in meadow or pasture (sod ground) the previous year. Inasmuch as the methods of seed bed preparation vary slightly, a separate description is given for each of the three.

CORNSTALKS

Cornstalks may be burned before the plowing is started. This is not considered a good practice from the standpoint of maintaining humus content in the soil. Some cornstalks are burned to assist in the control of the corn borer, even at the expense of the loss of humus. The practice of burning cornstalks in areas that produce much of the American corn crop is diminishing.

Cornstalks are usually disked previous to plowing. Sometimes a stalk cutter is used. With either method, an attempt is made to cut the stalk into pieces about a foot long or less. A complete covering of the stalks is essential in any program that is designed to control the corn borer. Most of the plowing that is done for corn following corn is done in the spring of the year. There seems to be some increase in the plowing of

stalk ground in the fall. This is made possible by prompt harvesting of the corn with the mechanical corn picker. Some farmers even prefer to plant corn which is a little early for the area, in order to be sure that the corn will be dry enough to pick and still allow time for fall plowing. This fall plowing of cornstalks seems to be more popular in Ohio and Indiana than in Iowa and Minnesota. In Indiana and in states where the rotation is winter wheat following corn, fall plowing is essential. Previous to the introduction of the mechanical corn picker, all the corn included in a corn and wheat rotation was cut and shocked and the wheat was put in between the shock rows. This seemed to be the custom, even though the fodder was not too useful for the feeding of livestock on every farm.

Land which has been in grain or forage sorghums should be handled in the same general way as corn ground. Residue left on the ground may be the entire stalk, such as grain sorghum, or only the roots of the crop used for fodder or silage. These may be plowed under in the same way as cornstalks. It is important that the plowing be done in the fall or early spring. An application of manure on a field that has grown any crop of the sorghum family is a considerable aid to the following crop of corn. A decay of the residue of sorghum within the soil retards the normal release of materials essential to the growth and hence the maturity of the corn crop. It appears that fall plowing or early spring plowing, plus the application of manure, for all practical purposes, eliminates any effect sorghum might have on the succeeding corn crop.

STUBBLE GROUND

A field from which small grain has been harvested is usually called stubble ground. Some fields are harvested with a binder, and the straw is removed, threshed, and put in a straw pile. In other fields the grain is harvested with a combine and the straw is left on the field. The straw, however, may be picked

up with a baler. The field may or may not have straw lying loose on the stubble. A good job of plowing requires that most of this straw be covered. In order to be covered, the straw should be rather evenly distributed ahead of the plow. Wet or moist straw chokes the plow and reduces the area plowed per hour. This straw is satisfactory humus. Careful operators do not burn the straw. The same method serves when corn follows a soybean crop, so far as the straw is concerned. Soybean ground may be plowed in the fall in preparation for the corn crop the following spring.

SOD GROUND

Alfalfa, sweet clover, red clover, timothy, brome grass and blue grass, and mixtures of them, and mixtures of other grasses used for pasture or hay are referred to as sod ground, when the next crop is to be corn.

Alfalfa probably requires more power for plowing than any of the grasses, with the possible exception of a thick sod of brome grass. In plowing alfalfa it is essential that all the plants be cut off by the edge of the plow. It is possible to add an extension to the plowshare to make sure that all the plants will be cut off. This extension should increase the width of the cutting surface of the plow by approximately 2 inches. The extension may be made near the nose of the plow on one side and by extending the plowshare on the other side. Any good blacksmith can make and attach an extension. The same device is very useful for plowing under sweet clover for corn. Alfalfa may be plowed under in the fall or the spring, depending on the labor supply and convenience of the farmer. Early spring plowing or fall plowing is much more satisfactory than late spring plowing.

Sweet clover, with the exception of Hubam Sweet Clover, is a biennial. If it is plowed under the same season it is sown, it will sprout up again. It may be plowed late in the spring to prepare a satisfactory seed bed. It does require careful

plowing to make sure that all plants are cut loose and turned over, and the extensions referred to in plowing alfalfa are useful in this case. Sweet clover that is used for pasture for the second season after sowing should be plowed before the plants die in the fall. If this is pastured heavily there should not be much top growth. If it is pastured lightly or not at all, there should be an abundance of growth above the ground. This growth needs to be thoroughly covered when the plowing is done.

To aid in plowing under heavy sweet clover, a piece of heavy wire, about 6 feet long, may be tied to the rolling colter on the furrow side and allowed to drag back under the dirt that is being turned over. This aids materially in covering the vegetation. The wire is also satisfactory in covering crops other than sweet clover. For plowing soybeans under, the land roller and wire are both useful. In some cases the wire is satisfactory in plowing under high stubble that remains after using the combine. The wire will last longer if it is fastened to the frame on the rolling colter by a small chain. Without the chain the wire will soon break off close to the knot where it is tied around the casting. The wire will wear out in the course of 100 acres or so at that place where it gets the most pressure from the dirt falling on it under the plow. Caution must be used so that the wire does not get wrapped in the plow wheels.

Alsike, red, and *mammoth clovers* are biennial crops and do not sprout again after plowing, like sweet clover. Timothy is often present with alfalfa, sweet clover, or other clovers. Timothy does not increase the difficulty of plowing.

Perhaps the two crops which cause the most difficulty in preparation of the seed bed are *bluegrass* and *brome grass.* Both grow a tough sod. Both require extra power to plow, and both require extra attention after plowing for the preparation of a good seed bed for planting corn. This extra work usually includes several more diskings or harrowings or both.

Plowing *soybean* ground requires no great amount of skill. It is necessary to be sure that the straw is properly scattered if an efficient job of covering is to be done. *Sudan grass, wheat,* and similar crops offer no problem in plowing unless they have considerable growth above ground, in which case the wire attached to the rolling colter will aid in covering the growth.

Plows used for preparing the seed bed are different from those used some twenty years ago. Most operators want a higher beam, a higher attachment for pulling, more throat just above the shin of the plow, a larger rolling colter, and a wider furrow. Early plows had the front end of the beam close to the ground when the plow was in the ground. It plowed a strip from 12 to 14 inches wide. The drawing attachment now is a foot or more from the ground, and the width of the furrow is likely to be more than 14 inches, often 16, and sometimes 18 or 20 inches. The rolling colter formerly was always a round disk, sharp on the outer edge. There is now on the market the so-called cut-away rolling colter. This consists of having about one-half of the colter cut smaller, by the use of several semicircular notches. These notches are 2 or 3 inches across and 2 or 3 inches deep from the sharp edge of the round colter. A new departure from this colter is made by making these notches 1½ inches wide and 1½ inches deep. Some operators find these smaller notches more efficient than the larger ones.

Much the same type of plow is usually used for contour plowing. The reversible plow which has one or two mold boards for the right hand and one or two for the left hand is sometimes used for contour farming. This plow was manufactured originally to work hillsides; it plows back and forth and throws all the dirt downhill. It has been adapted for use in irrigated areas because it does not leave any dead furrows or back furrows. A one-way disk plow is used occasionally in areas adapted for corn growing. The soil is turned by a series of disk blades rather than with a mold board. This one-way

disk plow is in the developmental stage. Its use now is mostly limited to lighter level soils of the western part of the corn-growing area.

DEPTH OF PLOWING

There is no uniform practice for controlling the depth of plowing for corn. The type of soil may require either deep or shallow plowing. The previous crop that was on the ground may influence the depth of planting. Crop residue to be covered may require deep plowing. Deep topsoil allows for deep plowing. All these factors, and many more, affect the depth of plowing.

Heavy black soils, well supplied with humus material accumulated through the centuries, usually need to be plowed deeper than some other soils. Often the water level below the surface in this kind of land determines the depth of plowing. If the water level is comparatively close to the top of the ground, shallow plowing may be the only kind which can be done. The depth of plowing is regulated by the moisture in the soil at the bottom of the furrow. If, at 7 inches deep, the soil is too wet to slide readily off the mold board, it may be wise to plow only 4 inches deep. Light sandy soil, uniform in fertility for 2 or more feet deep, may be plowed shallow. Sod ground, including pasture and meadow of all kinds, may have to be plowed deeper than adjoining fields that are not in sod. A little more depth to the plow often furnishes more loose dirt in proportion to the vegetation to be covered with the plow. This higher proportion of loose dirt facilitates the preparation of the seed bed with the disk and the harrow.

Cornstalk ground that has an abundance of crop residue left from the previous year often needs to be plowed 7 or 8 inches deep on rich land in order to cover the cornstalks to good advantage. Ample soil must be mixed with the cornstalks. The stalks need to be buried well below the level that will be reached when the corn is cultivated.

When the crop residue on top of the ground is almost absent, the depth of plowing may be around 5 or 6 inches, according to the judgment of the operator.

In some areas in the United States, the surface tillage is done by sweeps, in an effort to leave all the crop residue on top of the ground, shading the ground and offering protection against wind erosion. This residue also prevents exceedingly rapid run-off of any rainfall. The area so prepared for planting corn without plowing is not a very great percentage of the total 87,000,000 acres planted to corn in the United States. The change from animal power to tractor power in the major portion of the Corn Belt has had a marked effect on plowing. Most operators have increased the depth of plowing, when the plowing was done with tractors. This is not always true, however; with a high-speed tractor, some men plow shallow in order to get more ground covered in a day.

PREPARING THE SEED BED AFTER PLOWING

The universal tools used in the Corn Belt proper for preparing the seed bed after plowing are the disk and the harrow. A disk is a rolling cutter device which cuts the soil apart and moves the dirt sideways. A harrow is really an oversized garden rake. Sod ground usually requires two, three, or four diskings before the ground is sufficiently level and pulverized. For cornstalk or stubble ground, one disking is often sufficient, but the disk is nearly always followed with the harrow. The harrow does not necessarily destroy weeds or sprouts of weeds. The disk has a greater effect on weeds. The harrow is used to smooth the ground and to permit a more uniform depth of planting.

There are some machines appearing in the Corn Belt that are equipped with several duck-foot sweeps. Originally developed for summer fallow areas, these are gaining popularity in the western and northern part of the Corn Belt. These tools have a series of sweeps which are really oversized culti-

vator shovels built with wide edges which run a uniform depth 2 or 3 inches below the top of the ground. These tools are more effective than a disk against perennial weeds such as quack-grass. They are also more satisfactory against annual weeds if the annual weeds are more than 1½ inches high. The spring-tooth harrow is also an effective tool in preparing the seed bed where some of the most persistent perennial weeds are found, such as quack-grass, creeping Jenny, and morning-glory.

A plow may have one section of the harrow attached so that the harrow smooths the ground and breaks up the clods on two or more furrows that were turned the previous "round." The rotary harrow is satisfactory on heavier soils. This attachment is also used to level the furrows plowed the previous "round." If neither device is used attached to the plow, it is common practice in the Corn Belt to harrow the ground that has been spring-plowed within 24 hours after plowing.

Before the coming of the tractor on rubber, plows were designed to travel at 2 to 3 miles per hour and do a good job. Considerable improvement has been made on the shape and the slope of the mold board to insure minimum draft and maximum coverage of trash at a higher speed. Plowing was the first job taken over by the tractor when it arrived on the farm. However, the tractor has not arrived on every farm that grows corn in the United States. Where the fields are small, horses still do most of the work. This applies particularly to those areas just outside the great middle-west Corn Belt. This is particularly true of the area south and east of central Missouri, southern Illinois, southern Indiana, and western Ohio.

There are two rather new attachments for plows which may deserve mention at this time. The fertilizer attachment has been designed to distribute fertilizer at a uniform rate per acre, at the plow sole, which is the bottom of the furrow. The second experimental device is now called the sub-tillage attachment. This is a piece of strong steel with a small

sweep on the end which extends into the ground below the bottom of the furrow. In comparatively dry weather this loosens up the ground and has shown some promise in certain types of soil.

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CHAPTER VIII

CORN SOILS AND FERTILIZATION OF SEED BED

The best corn soils are well-drained, deep, dark, silt loams. Sandy soils, unless heavily fertilized or manured, are not desirable for corn, as they dry out quickly and are usually low in fertility. On the other hand, clay soils are, as a rule, poorly drained and too compact to produce the best corn.

Estimates made after extensive studies in soil analysis of the good corn land in central Illinois and northern Iowa indicate that the plowed soil of an acre contains about 1200 pounds of phosphorus, 4500 pounds of nitrogen, and 35,000 pounds of potassium. When properly managed, this type of soil will generally give annually enough nitrogen and potash for a fairly high corn yield. It is often beneficial to supplement the soil phosphorus, either by applications to the sod crop or directly to corn. As will be seen in Table 5, a 100-bushel crop of corn would require approximately 1 ton of an 8–8–8 fertilizer if the soil furnished none of these plant food elements. Since most programs of using fertilizer on corn call for 150 to 300 pounds of such a mixture as 3–12–12, it can readily be seen that most of the corn crop is made from the land, rather than from the fertilizer that is applied directly to the crop.

Corn is the heaviest feeding and most destructive to soil fertility of all our common crops. Only on the richest soils can corn be grown for more than two years in succession, with any assurance of maximum profit. In humid regions, corn yields may be maintained or increased by the use of: (1) crop rotation, (2) commercial fertilizer, (3) legumes, (4) manure and crop residues, and (5) good drainage.

CROP ROTATION

The all-important and economical way to maintain corn yields is to use a good crop rotation. What constitutes a good rotation will vary with the native fertility of the land, the depth of the topsoil, the slope of the land, and the inclination of the individual operator. As a general rule prairie soils of level topography can be maintained by using a cropping system which provides for one year of legume for each two years of corn. Timber soils may require a somewhat narrower corn-clover ratio than this, because they are lower in organic matter. As the slope of the land increases, it is necessary to reduce the corn acreage and to increase the sod acreage in order to diminish the water erosion problem. For typical rolling prairie land, a corn-corn-oats-meadow-meadow rotation is quite satisfactory, as is a corn-oats-clover rotation. Either of these rotations would furnish an acre of sod for each acre of corn. The rotation providing for 40 per cent of the land in corn may be more popular than the one providing for one-third of the land in corn.

The amount and type of sod crop or seeding are of great importance. An alfalfa-timothy mixture, preferably high in alfalfa, will give far better results in this five-year rotation than red clover-timothy seeding. A clover-timothy seeding is mostly timothy after the first hay year. Alfalfa and brome may be used as a meadow mixture. The brome crowds out the alfalfa, and when the brome becomes half of the crop it is time to plow. Brome draws heavily on all nitrogen supplies. The price of legume seed is seldom, if ever, so high that a farmer cannot afford a new seeding as an economy measure when the alfalfa stand becomes thin.

Few good rotations involve more than two years of corn in succession, and it is generally found that the second corn crop will yield from 10 to 20 per cent less than the corn crop following legumes. Whether to raise second-year corn on any

given farm depends in part on the comparative yield of feed from the second-year corn, as against alfalfa, soybeans, wheat, or whatever crop might be substituted for corn. Third-year corn is seldom desirable because of a depleted nitrogen supply, less satisfactory tilth following successive cultivations, and in-

TABLE 5

RAW MATERIALS USED BY CORN PLANTS ON AN ACRE PRODUCING AT THE RATE OF 100 BUSHELS TO THE ACRE *

Substance †	Symbol	Pounds per Acre	Approximate Equivalent
Water	H_2O	4,300,000 to 5,500,000	19 to 24 inches of rain
Oxygen	O_2	6,800	Air is 20 per cent oxygen
Carbon	C	5,200 carbon or 19,000 carbon dioxide	Amount of carbon contained in 4 tons of coal
Nitrogen	N	160	Eight 100-pound bags of a 20 per cent fertilizer
Potassium	K	125	Three 100-pound bags of muriate of potash
Phosphorus	P	40	Four 100-pound bags of 20 per cent superphosphate
Sulphur	S	75	78 pounds of yellow sulphur
Magnesium	Mg	50	170 pounds of Epsom salt
Calcium	Ca	50	80 pounds of limestone
Iron	Fe	2	2 pounds of nails
Manganese	Mn	0.3	1 pound of potassium permanganate
Boron	B	0.06	¼-pound box of common borax
Chlorine	Cl	Trace	Enough in the rainfall
Iodine	I	Trace	1-ounce bottle of tincture of iodine
Zinc	Zn	Trace	The shell of one dry-cell battery
Copper	Cu	Trace	25 feet of No. 9 copper wire

* Total mineral requirements shown in Table 5 are not determined on the same basis as those shown in Table 7. Table 5 includes all the corn plant. Table 7 is analysis of the corn grain only.

† The analyses for nitrogen, potassium, phosphorus, magnesium, and calcium were made on corn grown at Lafayette, Indiana, in 1938, 1939, and 1940. The other figures are from various sources. The composition of corn plants would vary on soils of different levels of fertility, and that of other types of crops would vary from that of corn in minor details.

creasing insect damage, particularly from the corn rootworms.

One of the main reasons for raising forage crops is to maintain our grain yields, particularly corn. For this reason many Corn Belt farmers might well afford sufficient cattle to pasture a fair acreage of rotation land, recognizing that a part of the

rent from pasture comes from the succeeding corn crop. Even though the gains on cattle may not pay the current rate of cash rent, the overall income of that system can well exceed the alternative of raising the corn without the cattle.

In view of the fact that some of the return from sod crops comes from high corn yields when the crops are plowed under, it is often desirable to put only one crop of corn on some fairly steep land every five to eight years, since the sod generally needs to be renovated about that often. Little, if any, washing takes place the first year after sod is plowed under, even on rolling land.

COMMERCIAL FERTILIZERS

Nitrogen. The first figure in a three-figure commercial fertilizer formula stands for the percentage of nitrogen (N) in the total mixture, the second for the percentage of available phosphoric acid (P_2O_5) and the third for the percentage of available potash (K_2O). Nitrogen is an essential part of all living cells and is directly associated with the protein content of all feeds. In fact the one way to determine total protein content is to analyze for nitrogen and multiply by 6.25. Available information suggests that the corn plants on 1 acre require 3 to 5 pounds of nitrogen the first month. During July and August, when the crop is making its most extensive growth and setting ears, it may require as much as 3 to 5 pounds of nitrogen per day. As a rough measure, it may be estimated that each bushel of corn contains 1 pound of nitrogen, and the stalk that the bushel grew on contains ½ pound. In other words the grain and stover on 100 bushels per acre yield of corn would contain roughly 150 pounds of nitrogen.

Under most systems of farming, the economical way to obtain necessary nitrogen supply is either to deplete the native fertility of the land, to furnish it by clover or manure, or to utilize a combination of these sources. The ordinary fertilizer used on corn would supply the nitrogen needs of the crop for

only the first month or six weeks' growth. Most of the nitrogen is furnished from clover, manure, or the original store of the black topsoil and depends on biological activity to make it available to the plant. Once the soil warms up and is aerated by tile or cultivation, or both, this activity is sufficiently high to take care of the needs of the corn plant on good soils. There may be good reason to furnish a little soluble nitrogen to help the plant bridge the gap between planting and warm weather, should a cold, wet, spring season be encountered.

TABLE 6

FERTILIZER RESPONSE AS AFFECTED BY YIELD LEVEL

Webster, Clarion soil areas in Iowa: 40 fields planter; 11 fields broadcast

Group	Yield Range	Number of Fields	Yield without Fertilizer	Yield with Fertilizer *	Difference in Yield
			bushels	*bushels*	*bushels*
Lower third	21.6 to 61.6	19	53.0	64.6	11.6
Middle third	65.2 to 74.6	16	68.8	74.4	5.6
Upper third	75.2 to 92.3	16	80.6	82.0	1.4
All	21.6 to 92.3	51	66.8	73.1	6.3

* Fertilizer was applied at the rate of 150 pounds with the corn planter attachment on forty of the field tests. Broadcast applications were at the rate of 300 pounds per acre. The fertilizer used was 3–12–12 in both methods of application.

Fields which would make less than 65 bushels without fertilizer could reasonably be expected to respond enough to pay for broadcast applications of 3–12–12 at 300 pounds per acre. Fields yielding up to 80 bushels would respond enough to pay for 150 pounds of hill fertilizer put on with a planter.

On land which has not been well managed or which has a very shallow topsoil, the supply of nitrogen may be inadequate during the July and August period to make top yields. Under such circumstances the application of large amounts of high nitrogen fertilizer will increase corn yields substantially. Whether it pays to do so will depend on the price of nitrogen

fertilizer, the price of corn, and the risk involved in using such a program. In many experiments it has been found that an extra bushel of corn was obtained for each 2 pounds of nitrogen added. In many others, as much as 4 pounds of nitrogen was needed to obtain an increased yield of a bushel. When large quantities of nitrogen are added, some is usually applied before or at the time of plowing the ground. Fertilization with nitrogen as a side-dressing after the corn is up is common. Satisfactory returns may be obtained by making applications as late as the last cultivation. Too much soluble nitrogen put on at planting time could cause injury to germination, in the event of a dry period immediately following the planting.

A deficiency of nitrogen can be recognized by partial or complete drying of the lower leaves of the corn plant and a yellowish-green color. A well-supplied corn plant is dark green in color, whereas a deficient one first becomes lighter green, then quite yellowish, and the lower leaves begin to fire. The firing starts at the tip end, proceeds down the midrib, and out. This type of firing is commonly associated with dry weather, but it actually is a danger signal indicating that the supply of nitrogen is inadequate for the needs of the plant. A possible reason, for associating it with dry weather is that nitrate nitrogen is quite soluble, and during dry spells evaporation exceeds the rainfall. There is continuous movement of water upward, resulting in the deposition of a nitrate crust on the surface of the soil out of reach of the roots. The "million-dollar rain" which often falls in the Corn Belt during the summer months may be fully as valuable for putting the limited supply of nitrogen back within reach of the corn roots, as it is for the water which it furnishes. When large amounts of nitrogen are applied, it is believed that deep placement is advantageous to counteract this upward movement of nitrogen, especially in dry periods.

Phosphorus. The phosphorus content of most soils is not particularly high, and even under the best management phos-

phorus will be depleted because it is contained in the meat and the milk and the bones of all livestock products sold off the farm. For this reason most of the early fertilizing was directed toward the phosphorus problem. In general the first thing after agricultural limestone in a soil improvement program would be the application of phosphate fertilizers. A soil treatment program which provides enough phosphorus, either in the form of rock phosphate or superphosphate, to produce maximum legume growth also supplies ample phosphorus for optimum corn yields.

A healthy corn plant should contain about 0.30 to 0.35 per cent phosphorus concentration in its tissues. When the corn plant contains less than 0.20 per cent phosphorus, a stunted plant results, and purple leaves develop. For the first two weeks after germination, the young seedling obtains its phosphorus from the supply in the seed. After this supply is exhausted, the young plant is depending on a small root system for obtaining phosphorus from the soil. This is often a critical stage in the growth of the corn plant in relation to phosphorus supply. The plant may show a deficiency, even when a generous supply is available in the soil, for the reason that the short roots are in contact with less than 1 per cent of the soil that eventually furnishes nutrients. This factor probably explains why best results have generally been achieved from the application of fertilizer with an attachment on the corn planter. A fairly high concentration of soluble plant food is placed within an inch or two of the seed, thereby having it within reach of the small root system of the young corn.

Another factor involved in this method is that soluble phosphates tend to become less available when in contact with the soil. Placement of fertilizer in a band or strip parellel to the row puts it in contact with less soil than a broadcast application (scattered evenly over the soil surface), providing less opportunity for reversion or fixation to take place.

A second critical stage in phosphorus nutrition is at flowering time when the tassels and shoots begin to form. The

phosphorus in the corn plant tends to move from the leaves and stalk into the grain. If the corn plant has had a generous supply of phosphorus up to this time, there may be sufficient phosphorus in the plant system to supply the normal concentration in the seed. In early development, kernel analysis may show as high as 0.60 per cent phosphorus. If the plant has not received enough phosphorus, additional phosphorus is absorbed from the soil at this stage.

TABLE 7

MINERAL CONTENT OF CORN GRAIN (MOISTURE-FREE BASIS) *

Mineral	Number of Analyses	Content (Per Cent) Maximum	Minimum	Average
Potassium	44	0.9200	0.2200	0.4000
Phosphorus	197	.8000	.2300	.4300
Sulphur	22	.3000	.0400	.1400
Magnesium	121	.2700	.0900	.1600
Chlorine	16	.0730	.0040	.0240
Sodium	18	.1250	.0010	.0480
Calcium	127	.0450	.0060	.0150
Iron	4	.0050	.0025	.0037
Zinc	1	..	..	.0020
Manganese	13	.0019	.0005	.0013
Copper	6	.0017	.0004	.0008
Barium	1	..	..	.0009
Titanium	..	..	..	.00014
Selenium	..	..	..	..
Nickel	..	..	..	.00014
Arsenic	2	.000036	.000003	.000019
Iodine	21	.000065	.0000063	.0000177
Cobalt	..	..	..	.0000011
Boron	..	..	..	..
Bromine	..	..	..	.00017

* Kenneth C. Beeson, "The Mineral Composition of Crops," *U. S. Dept. Agr. Misc. Pub.* 369, Northern Regional Research Laboratory, CDA-42, March 26, 1945.

As much as half the total phosphorus supply in typical soils will be found in the organic matter. Since this phosphate is

released by biological activity in much the same manner as nitrogen is made available and also by action of enzymes on the roots, the warm temperatures and good aeration afforded with cultivation of corn during the summer months stimulates the release of organic phosphorus. Since this store of phosphates is available during the midsummer period, it is likely that feeding mineral phosphate to the corn during the early summer period is apt to be most beneficial.

Phosphorus in a fertilizer formula is quoted as percentage of phosphoric acid (P_2O_5). Most fertilizer formulas for use on the corn crop involve a fairly large middle number, such as 2–12–6, 4–16–0, 3–18–9, and 3–12–12. The fact that the young corn plant may be stunted if grown on soil deficient in phosphorus and that vegetative growth is tremendously increased by hill or row applications of phosphorus has led some farmers to term such formulas as "starter" fertilizer. Probably this terminology is valid, because one of the main functions of using fertilizer at planting time is to assure a fairly large and vigorous corn plant to begin the midsummer growing season when carbohydrates are manufactured within the plant in great abundance.

Potash. Potash in any fertilizer formula is the content of potassium quoted as potash (K_2O). When soil chemists were first interested in the total mineral content of soils, they did not foresee a potash problem in the Corn Belt, because Corn Belt soils may contain as much as 40,000 pounds of potash in the surface layer. More recent research has shown that a large part of this total supply is locked up in the primary minerals and may not be available to growing crops. The very small fraction which is held by the clay particles seems to be the most available part. Some movement of potash from the nonavailable form to available forms takes place as the growing crops remove the available potash from the soil.

A good corn soil should contain 200 pounds of available or exchangeable potash and should have a potash supplying power great enough to replace 200 pounds in the exchangeable frac-

tion within the first season after growing a crop that contains as much potash as a 100-bushel crop of corn or 3-ton crop of alfalfa. Certain old, highly weathered soils such as the gray, flat lands of southern Illinois and Indiana do not have a sufficient reserve of exchangeable potash. Here it is necessary to supply fairly large quantities of muriate of potash, or mixed fertilizer high in potash content, in order to obtain maximum corn yields.

Potash availability is also affected by drainage and aeration, as well as by the concentration of other bases, particularly calcium. For this reason soils that drain slowly in the spring very often show a marked response to potash fertilization, even though the exchangeable supply may be reasonably high. Potash is especially needed on peat and muck soils. This apparent deficiency, both from excess water and lack of air, has been demonstrated in greenhouse experiments. Under field conditions the excess water and lack of air generally go together, so it is not too important to know which causes the trouble. When such conditions are encountered, higher applications of potash are needed. For this reason most land which has been tile drained in order to raise corn would be suspected of needing potash more than soil that is naturally well drained.

Potassium is also apt to be deficient in soils that have an excess of lime. These high lime spots are often termed alkali by farmers, although true alkali of the west is generally an excess of sodium rather than of calcium carbonate. Most grain crops require fairly large quantities of potassium. The legume crops can, to some extent, substitute calcium and magnesium for potassium in their growth process. Oats do not show as much of a potassium deficiency on high lime spots as corn, probably because the sodium ions substitute for the potassium ions in the plant. The corn plant is not able to assimilate much calcium, magnesium, or sodium and, therefore, is more sensitive to the supply of potassium than are the other crops grown in the Corn Belt.

Since corn has a high potassium requirement, amounts sufficient for the ordinary yields of the old varieties may be inadequate for the high yields that are possible with the better hybrids. For this reason, mixed fertilizer containing both potassium and phosphorus has been effective in growing high yields of corn on productive soils where phosphorus alone would not have given such good results.

A corn plant that is starved for potassium has a short stalk and somewhat stunted growth, with the burning showing up around the outer edge of the lower leaves. The ears from potash-deficient land are generally "chaffy" and poorly filled. One may get profitable response from applications of potash, even before the plants show any acute deficiency symptoms. Either nitrogen or potash deficiency is apt to show up after the corn is laid by. Therefore, these deficiencies are frequently overlooked. When the deficiency shows up before the corn is laid by, there is still time to side-dress effectively with nitrogen and potash fertilizer. Where symptoms are seen later in the season, they simply serve to point out that the corn yield is limited by deficiency of either potash or nitrogen or both.

LEGUMES

Alfalfa is probably chief among the legumes according to the plant food made available for the corn crop which follows. This is particularly true if the alfalfa has been allowed to stand two, three, or more years. Alfalfa grows a tap root sometimes more than 30 feet long, going straight down, about the size of a lead pencil. There are literally thousands of these plant roots going down into the earth while the alfalfa is growing. They certainly must bring up something that the alfalfa needs in addition to water. In excavating for building foundations in a field in which corn followed alfalfa, corn roots have been found following the decaying alfalfa roots to a depth of 10 feet or more.

These openings in the soil made by the alfalfa roots also allow moisture to go down. When moisture goes down, it does not run off and wash some of the soil along with it. Since alfalfa responds readily to phosphate fertilizers, it certainly deposits phosphorus in some organic form in the soil. This reservoir of fertility is available for the succeeding corn crop. The same may be said of sweet clover and other clovers. They are not, however, so deep rooted as alfalfa.

MANURE

One ton of good manure is equivalent to 100 pounds of commercial fertilizer, 10–5–10. It really has greater value than that, since the manure includes a great number of the trace elements which were referred to earlier in this chapter as a part of a mature corn plant. In addition this manure has some substances not yet isolated and not yet named. Their action resembles that of vitamins or perhaps enzymes. The effect of these substances and how they act are still unknown. In addition, manure, which usually includes straw or other crop residues, supplies quantities of humus.

Careful estimates indicate that the animal manure produced in Iowa in any one year is worth more, when calculated against the producing effect of commercial fertilizers, than the combined value of Iowa's oats and hay, or than one-third of her corn crop. It is possible to grow corn on the same land four or five years in succession if the field has an application of from 7 to 10 tons of manure per acre each year. The rootworms will cause some damage, but the fertility is not the controlling factor in the yield. A 1000-pound cow produces 1 ton of manure per month; other livestock produce a proportionate amount. If this manure is promptly applied to the field, there is a minimum of waste. On the other hand, if it is allowed to pile up outside in the rain, much of the value is washed away. Slow rotting and heating start. The odor from such manure should remind a corn grower that nitrogen is disappearing.

As an example of rapid soil rejuvenation, a 40-acre field produced 60 bushels of corn to the acre. The next year this field received enough agricultural limestone to make it satisfactory for growing legumes. Six hundred pounds of rock phosphate and 25 tons of barnyard manure were applied per acre. A crop of inoculated soybeans was sowed in June. The beans were plowed under when the pods were about three-fourths mature size. The following year corn was grown again, yielding 116 bushels to the acre. There was a tremendous amount of reserve fertility that was not removed by the 116 bushels of corn. Not every corn grower has a liberal supply of manure, but often more valuable manure is allowed to waste than is applied to the fields.

TABLE 8

EFFECT OF MANURE ON THE YIELD OF CROPS IN A FOUR-YEAR ROTATION

Webster Series, Agronomy Farm, 1915–1938, Iowa Experiment Station, Ames, Iowa

	Yield per Acre		Increase per Acre When Manured	
Crop*	No Manure	8 tons Manure †	In Yield	Per Cent
Corn (bushels) (first year)	56.1	67.9	11.8	21.1
Corn (bushels) (second year)	51.4	61.1	9.7	19.1
Oats (bushels)	60.0	63.7	3.7	6.2
Clover (tons)	2.12	2.70	0.58	27.3

* Includes twenty-three corn crops (first year), twenty-three corn crops (second year), twenty-three oat crops, and nineteen clover crops.

† Manure applied on the clover sod.

Feed yards and barn lots. Feed lots and barn lots may be floored with cement. From this cement floor the manure may be readily cleaned with a mechanical manure loader and taken to the field without much work. A cement floor for barnyards and feeding floors is a long-time investment toward soil productivity and makes possible the conservation and use of fertilizer produced on the farm.

DRAINAGE

Drainage is the lowering of the water level by either open ditches or tile. When land is used for growing corn, a moisture content of from 15 to 30 per cent is desirable. Clay soils composed of small particles hold more nonavailable water than soils containing coarser material. If it is possible to make a mud ball, the soil is too wet for field work. A great portion of the corn land that needs draining has been tiled. This tile allows excess water to drain away. Good drainage lowers the water level in an entire field. After drainage, legume roots grow down to the water level. Useful bacteria within the soil must have air. They do not live and work below water level. There is very little, if any, fixation of nitrogen in the soil by either plants or bacteria below the water level. Tile also aids in cultivation. The preparation of the seed bed or cultivation of the crop is usually delayed until the wet portion of the field is dry. Drainage of the wet portion permits preparation of the seed bed and corn cultivation for the best advantage of the crop. The cultivation does not have to be timed by the inconvenient presence of any excessive moisture in the field.

Though much of the corn land has been tiled, this tile is not so satisfactory now as it was originally. Continuous cropping of heavy, black, silt soils with cultivated crops reduces the effectiveness of tile. As the tiles cease to function certain adverse conditions inevitably follow. The decaying roots that once grew down and allowed air to penetrate disappear gradually, from year to year. Movement of the water from the land between the strings of tile is less rapid. The water level becomes higher, aeration is less, and bacterial activity within the soil is reduced. All these things mean a diminished yield and later maturity of the corn crop. A striking example of later maturity is given by certain counties in the main portion of the Corn Belt which practiced corn-soybean rotation

rather continuously from 1940 to 1947. In January 1947 some of these counties did not have a single crib of corn dry enough to permit sealing of the corn for the purpose of obtaining a loan from the Commodity Credit Corporation, U. S. Department of Agriculture.

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CHAPTER IX

PLANTING

Most corn is planted by machinery. According to our present corn-growing customs, corn is planted in rows from 28 to 42 inches apart. Two or four rows of corn are planted on one trip across the field. There are a few machines that plant more than four rows at a time. Corn planted by machinery is usually checked, drilled, or power dropped.

A corn planter equipped to plant checked corn requires a wire stretched from one end of the field to the other. This wire, known as the check row wire, has knots at regular intervals. Perhaps the most common distance between two knots is 40 inches. It is possible to buy a wire with knots closer together than 40 inches. The wire is attached to stakes at ends of the field. When the operator is ready to begin planting, he slips the wire into the fork on the planter. When the planter moves forward, the knot in the wire moves the fork towards the rear of the planter, and this action releases the seed into the ground. When the operator arrives at the other end of the field, he reverses his machine and is ready for the return trip. He gages his distance from the previous planting by means of a mark made on the ground by an attachment on the planter. This marker gives him a guide for driving parallel to the previous trip across the field. Before he starts across again from either end of the field, he takes up the stake that holds that end of the wire and moves it to a point immediately behind the center of the planter, again placing the wire in the fork and proceeding as before.

Full instructions on operation of a corn planter will not be given here. However, a few general statements about the

difficulties in planting corn may be helpful. The kernels that are to be planted at any one knot are at the bottom of the shoe, that portion of the corn planter which travels in the ground and makes an opening or place to plant the corn. These kernels are released when the knot moves the fork towards the rear of the planter. The fork moves forward again

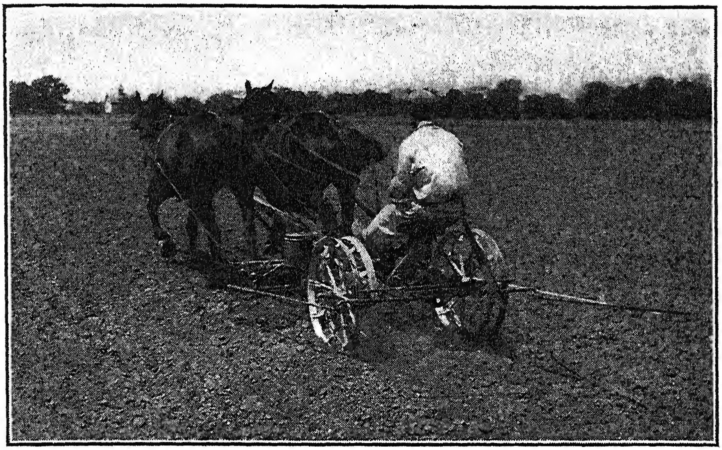

FIG. 19. Two-row corn planter checking corn that is planted so that the cross rows drop by means of a wire at straight right angles to the forward motion of the planter.

by means of a spring and is then ready to plant the next hill.

Most older corn planters are designed to check satisfactorily if the operator does not exceed $2\frac{1}{2}$ miles per hour. If the planter is operated at a greater speed the kernels have a tendency to be carried too far forward. It must be remembered that the second trip through the field is in the opposite direction to the first. Any distance that the kernels are carried forward, or past the knot in the wire, produces a row that is not uniformly straight crossways of the field. If the corn planter is a four-row corn planter and is traveling north and carries the corn $1\frac{1}{2}$ inches forward because of excess speed, on the return trip it carries the corn another $1\frac{1}{2}$ inches forward in the oppo-

site direction, and the four hills planted on the second trip north will be 3 inches out of line. A speed of $2\frac{1}{2}$ miles per hour is quite satisfactory for horses planting corn. The recent use of tractors as power for planting corn has demanded new improvements on the corn planter to compensate for more speed. Much experimental work has been done by corn planter manufacturers to permit traveling at speeds of 5 miles per hour or more and still have straight rows crossways of the field.

This experimental work consisted in building a new shape for the channel leading from the corn planter box to the ground. Careful investigation indicated that some of the kernels bounced when they struck the bottom and therefore went through the bottom valve a little later than the kernels that did not bounce. With the use of slow-motion moving pictures, the manufacturers are redesigning the corn planter and improving the operation of check-rowing.

The corn planter wire mentioned above is an important and sometimes a rather elusive part of a corn planter. Every knot on this wire always moves an inch or more in the same direction as the corn planter. This movement of the wire in conjunction with the corn planter is called the "creep" of the wire. The creep of the wire is exaggerated near the ends of the field with the two-row planter and even more so with the four-row planter.

The operator, when he resets his stake at the end of the field, needs to know "how to plant corn." If the wire is too loose, it will creep more and the planting will be irregular. If the wire is too tight, there is more creep at the ends of the field. Inexperienced operators often set their stakes an equal distance from the fence at the end of the field. This may be satisfactory if the fences at the two ends of the field are parallel. A corn planter wire stretches a little every time it plants across the field. It is not uncommon to have the wire stretch as much as 3 feet in the planting of 40 acres of corn where the rows are $\frac{1}{2}$ mile long.

Perhaps the best method of determining how good a job the operator is doing is to investigate how the hills are lining up in the crossways rows some 6 or 7 rods from the end of the field. If the operator uncovers the corn he dropped going in

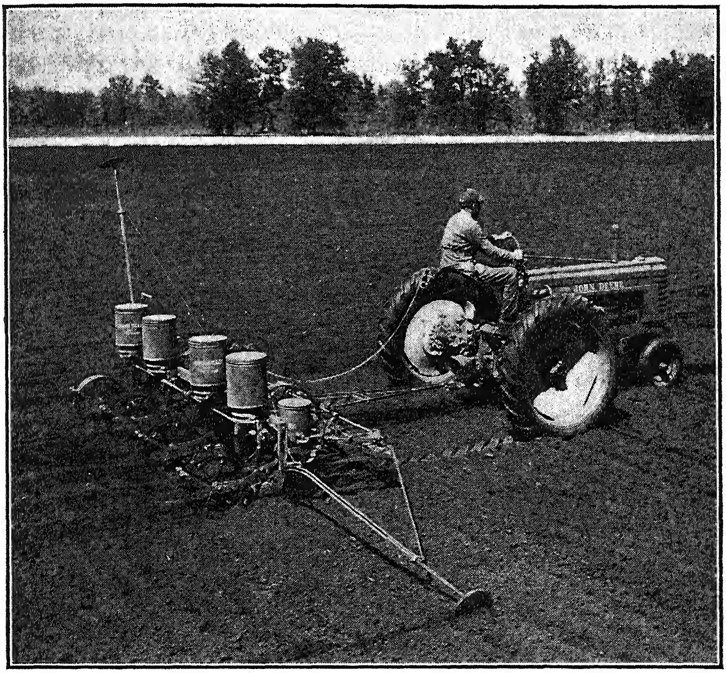

FIG. 20. Four-row corn planter drilling corn. This picture also shows fertilizer attachments. The check row wire is absent. (Courtesy John Deere Plow Co.)

one direction and also the corn he dropped in the other direction, he can determine how far he is missing an absolutely straight row crossways. He must then determine how far off he is on either side of the specific knot in the wire that released the kernels which planted that series of hills. He can make two adjustments. One is to adjust the tension of the wire, which may be done by altering the position of his stake

at the end of the field. The other adjustment is on the planter itself. If the adjusting equipment is properly used, the hills may be planted farther forward in their relation to the fork on the planter which releases the kernels, or they may be planted a little farther behind the fork. These adjustments may be more necessary on shallow planting than they are on deeper planting. Certainly they are more necessary if the speed is more than 2½ miles per hour.

TABLE 9

STAND AND YIELD ON THREE FIELDS, WITH AND WITHOUT FERTILIZER
Iowa Experiment Station, 1946

Soil Type	Number of Stalks		Yield—Bushels per Acre	
	Per Hill	Per Acre	Check	8–8–8 Fertilizer
Field 1	2.0	7,800	51	60
(Webster clay loam)	3.0	11,800	59	69
	3.8	14,900	66	78
	4.5	17,600	55	82
Field 2	1.9	7,600	55	64
(Clarion loam)	2.6	10,200	70	72
	3.2	12,600	75	85
Field 3	2.5	9,800	107	109
(Wabash silt loam)	3.4	13,500	128	124
	4.1	16,200	136	134
	4.5	17,600	127	137

Drilled corn is planted with the same machine as checked corn. The adjustments on the planter are so arranged that one kernel of corn is released at a time. These kernels may be spaced in a row, from a few inches to 2 feet or more apart, according to the desire of the operator. Drilled corn does not permit cultivating the rows crossways and it is therefore used in fields with comparatively few weeds. There is evidence to show that drilled corn has a slight yield advantage over checked corn. Drilled corn is extensively used in strip cropping and contour farming.

Power-dropped corn is similar to drilled corn with one exception. Two kernels instead of one are usually planted in one place, and they are released by power, operated either by the tractor or by the wheels of the planter. Power-dropped kernels are planted in hills from 16 to 18 inches apart in the row. The exact distance between the hills in the row is regulated by the operator.

How many kernels to plant per hill or per acre is a problem attracting the attention of corn growers. The rate of planting, or kernels per hill, later develops into stand per acre. Not every kernel planted produces a mature stalk. The number of mature plants per acre present at harvest time is the important consideration.

Corn planters are usually equipped with a variable drop lever that regulates approximately the number of kernels dropped per hill. Corn planter operators usually expect to use a corn planter plate of such size that slightly more than the indicated average number of kernels will be planted. Research indicates that, when the variable drop levèr is set

at 2 kernels, 2.0 stalks mature;
at 3 kernels, 2.8 stalks mature;
at 4 kernels, 3.4 stalks mature; and
at 5 kernels, 4.2 stalks mature.[1]

Table 9 shows rate of planting, stalks per acre, and yield per acre, with and without the use of fertilizer. The Iowa Experiment Station results show that the addition of 4000 stalks per acre to an average stand will increase the yield 8 to 16 bushels per acre on a highly fertile well-fertilized field. The thicker stand results in smaller ears even on rich and fertilized fields. Shelling percentage remains about the same for smaller ears. In a dry season it is possible to get too many stalks per acre and thus reduce the possible yield. Land of low fertility does not produce increased yield with an in-

[1] To obtain 5 kernels per hill, 1 kernel was added to the hill planted as 4 kernels.

creased rate of planting unless liberal amounts of fertilizer are used.

Most of our corn is still planted in rows 40 inches apart. Sometimes the space between the rows is as narrow as 36 inches, and some experimental work has been done to indicate an advantage in increased yield when the rows are closer together than 40 inches. However, all standard farm machines are constructed to handle a corn crop planted in rows 40 inches apart. This includes corn planters and listers, corn cultivators, corn binders, two-row field choppers, two- or four-row corn pickers, and tractors and wagons. In fact the distance between rows is "frozen" because of the great change that would be required in the machinery.

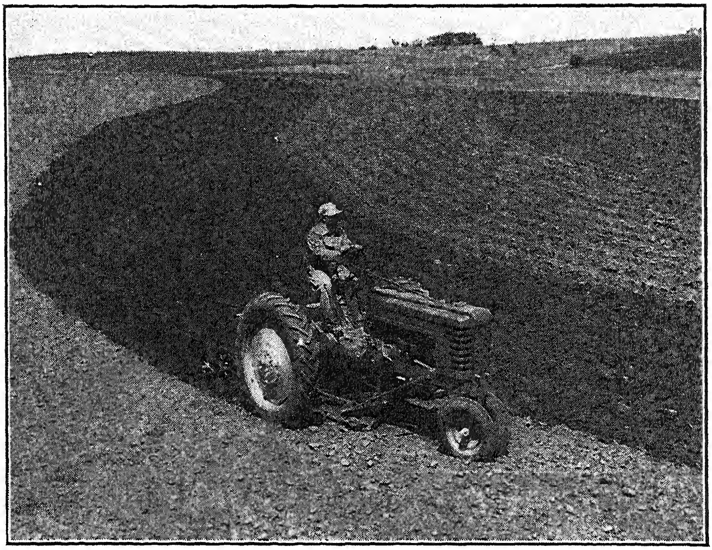

FIG. 21. Two-row integral lister, planting corn on contour. (Courtesy John Deere Plow Co.)

There is an old saying that seed should be planted according to its diameter. "Plant seed in the soil so that the distance

of the seed from the top of the ground is ten times the diameter of the seed." For corn, that would mean about 2½ inches deep, which is a very satisfactory depth to plant corn. It may be planted shallower if the moisture is closer to the top of the ground. The depth of planting has nothing to do with the depth of the root system. A shoot starts up and the root grows down from the kernel. The permanent root system starts according to the conditions between the top of the ground and the lowest point at which the roots have penetrated the earth by the time the permanent roots begin to form. Where the soil is sandy and warm, most operators plant corn a little deeper than is the practice in heavier soils that do not warm up so rapidly in the spring. Another factor in planting corn is the seed bed. Irregularity in the top of the ground may require part of the corn to be planted more than 2½ inches deep to insure covering all the seed.

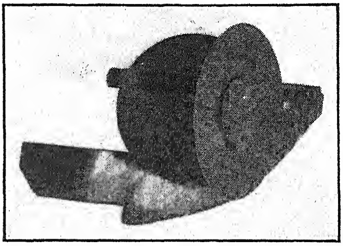

Fig. 22. A corn planter shoe showing position of the disk furrow opener. Disk furrow openers are used where some control of wind erosion is advisable and where drainage of the field is excellent and the soil is somewhat sandy.

Planting corn with a lister is similar to drilling corn. A lister is in reality a double-mold board plow. The kernels are planted in the furrow made by the lister. This practice is used in areas in the United States where the rainfall is usually a controlling factor for maximum corn yields. It is also used for contour planting. Listing of corn is a practice particularly adapted in the United States to the narrow area on either side of the Missouri River. Much of the corn in this area is listed. Apparently, hybrid corn has eliminated some of the advantages of listing. However, preparation of the seed bed requires less labor. One operation makes a complete job.

A furrow opener is a corn planter attachment. It is used on

land that has had a complete preparation of the seed bed to allow shallow planting in a shallow furrow. A furrow opener is not satisfactory in heavy soil. It is used in light or well-drained soils, not subject to water erosion. The advantage here is that the seeds are lower down than they appear in the row. This allows for moving more dirt around the plants and still leaves the field comparatively level when the corn is laid by.

We should not assume that all corn is planted with a two- or four-row planter. In parts of the United States, a considerable area of corn is planted with a hand planter. The operator pushes the planter into the ground and releases one or two kernels. He then picks up his planter and moves on to the next hill. Some corn is also planted with a one-horse drill. This machine deposits the corn in a row, similar to drilling. A lot of sweet corn is planted with a hoe in gardens all over the United States. No great area of corn on any one farm is planted by one-row drills or by hand. These practices are used on land in those portions of the United States where corn is not an important commercial crop. Hillsides too steep for use of machines are so planted.

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CHAPTER X

CULTIVATION

The average corn farmer spends about six and one-half hours in man labor to grow an acre of corn. This includes all the work from the beginning of the preparation of the seed bed to the harvesting of the crop. Cultivation is from one-third to one-half the job. The principle of cultivation followed by most farmers is to cultivate the crop as many times as possible before the corn gets too high to cultivate. Most farmers should keep in mind the reason for cultivating and follow the cheapest and easiest way to accomplish the desired results.

NECESSITY FOR CULTIVATING

Controlling weeds is the all-important object of cultivation. Cultivation should be done without cutting the roots of the corn. There is a generally accepted belief that corn will yield as much or more without cultivation as with cultivation, provided that there are no weeds.

Cultivation begins before the corn is planted. The most satisfactory seed bed is free of all growing weeds and does not have a crust on top formed by previous rain. Some corn planters are equipped with furrow openers which move all the weeds out from the row, even though they may be just sprouting. There is a tractor corn planter with a corn cultivator which stirs the ground immediately ahead of the planter, two or more rows at a time.

CULTIVATORS

Following any cultivation that may be done previous to planting, the most common follow-up method of cultivation is with the weeder, the harrow, or the rotary hoe. The weeder stirs about 1 or 1½ inches of the top of the ground

FIG. 23. Two-row tractor cultivators. (Courtesy J. V. Gorder.)

by means of long fingerlike teeth. When the weeds are small and the soil is loose, the weeder does nearly a satisfactory job of killing young weeds. If the ground is hard and some of the weeds are of considerable size, the weeder is not a very effective tool. The harrow is used more commonly than the weeder throughout the corn-growing area. If the harrow follows the corn planter before the corn is up, it does very little damage to the corn. Also, if the weeds are small the harrow is satisfactory for weed control.

A one- or two-horse cultivator may be used to till the soil on either side of one row. A two-row cultivator drawn by three or four horses was formerly rather common in the Corn Belt area and is still used to some extent. In the Corn Belt proper the most common cultivator in use now is the two-row tractor-mounted cultivator. In addition to these cultivators,

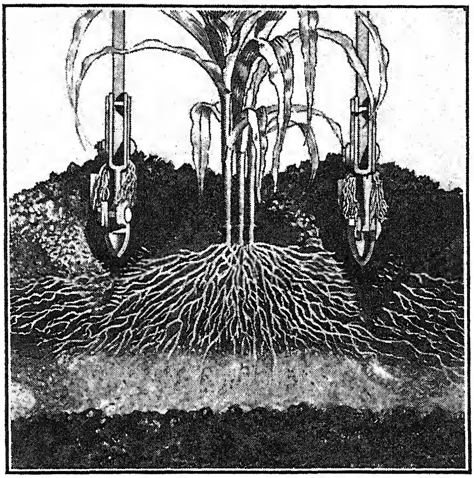

FIG. 24. Spear point shovels cutting roots of growing corn when cultivation is too deep and close to the plant.

there is the rotary hoe. The rotary hoe can be used either before or following the first cultivation. Essential usefulness of the rotary hoe depends on the condition of the ground. It works best if there is a little crust on the ground, soft earth underneath, and no excessive moisture. The rotary hoe is one tool that works best at high speed, 5 to 7 miles per hour. It may cultivate two, four, or more rows. Previous to the introduction of tractors in the Corn Belt, a greater portion of the cultivation was done with shovels to stir the ground. The shovels were of various shapes, but the essential part was a sharp point that was bent forward to help keep it in the

ground. These sharp points made it easier for the operator to maintain uniform distance between the two shovels which were on either side of the row. These shovels are still greatly used on horse-drawn cultivators.

The common equipment for a tractor cultivator is a sweep. The use of the sweep is an efficient cultivating method. It was not employed extensively previous to the use of tractors for corn cultivation. The weight of the tractor holds the sweep in the ground, and hence it does a satisfactory job. A sweep is more difficult to keep in the ground than a shovel, but it is satisfactory because of its method of cutting all the weeds about 1½ inches below the level of the ground as the ground is stirred.

There is a general practice of using some kind of shield in cultivating corn the first time to prevent dirt falling on the small corn. If corn is covered with dirt it usually does not survive. These shields may be made out of sheet iron. One pair of shields moves on either side of every row that is cultivated. There is an increasing custom of substituting parts of the rotary hoe for the shields by attaching the moving parts of the hoe to the cultivator so that they stir some ground right next to the row of corn and at the same time protect the corn from moving dirt.

For the first cultivation with the two-row tractor cultivator, 2 or 2½ acres per hour is satisfactory. Many operators do more than this. The first cultivation is the most important and, therefore, should be done carefully. Some of the corn will be destroyed by covering or plowing out. As a counterbalance against this loss of stand, more kernels may be planted per acre than are expected in number of plants per acre at harvest time. The generally accepted figure of reduction is about 10 per cent of mature plants below the number of seeds planted.

The second cultivation on check corn is crossways to the first, to remove the weeds and most of the ridges in the row that was caused by the first cultivation. The cross rows are

never quite so straight and easily cultivated as those in the direction planted. It is usually necessary to set the cultivator shovels or sweeps wider for cross cultivating than was necessary for the first.

The third cultivation may be faster than either of the other two. Efficient work indicates a speed of four to five miles per hour as satisfactory. Careful operators pay particular attention to adjust the cultivator so that it operates to the end of every row.

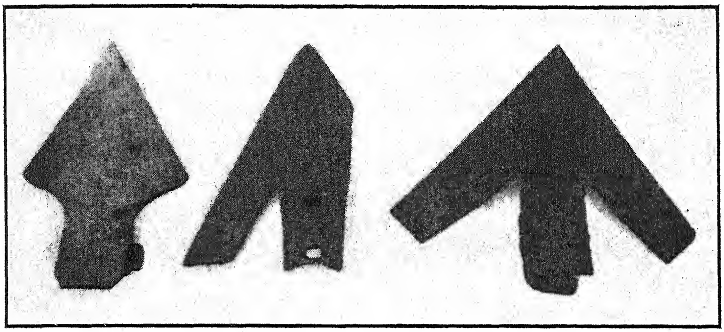

FIG. 25. From left to right, spear point shovel, half sweep, and sweep. The spear point shovel was used extensively on horse-drawn cultivators. The sweeps are almost universal equipment for tractor-drawn cultivating.

Listed corn is comparable to drilled corn, except that it is planted in an open furrow. The original preparation of the ground and planting are all done in one operation. The cultivator following a lister must be adjusted to move the dirt slowly towards the row. Some dirt is moved at the first cultivation, and additional dirt is moved during the following cultivations. This offers an opportunity to cover the weeds in the row if they are smaller than the corn. Listing is essentially useful in areas where the rainfall is, or may be, deficient for maximum growth of corn. If the dry weather arrives in July and August, the corn roots are farther down in the ground. Listing is a cheap, easy way of preparing the seed bed, plant-

ing, and cultivating. However, hybrid corn is doing away with listing in some sections, because hybrid corn produces greater returns per acre and therefore justifies more labor for growing a crop.

CONTOUR CULTIVATION

Contour farming is following the latest development of the U. S. Department of Agriculture soil conservation program. Contour corn is always drilled or listed. It is, therefore, cultivated in only one way, and an effort is made not to ridge the ground but yet have enough movement of dirt by the cultivator to help prevent the water from running crossways of the corn row. Much the same tools and cultivating methods are used for growing corn on the contour as are used on level ground.

Contour cultivation may require some separate adjustment of cultivating tools and a little more attention to following the row around curves. Increased yields often are obtained by contour, as compared with similar land planted up and down the hill.

GEOGRAPHY AND CULTIVATION

There is a wide variation in the United States and in the world in the methods used in cultivating corn. In areas where corn is used for human food, the problem is distinctly different from that in the Corn Belt. The most primitive form of cultivation is the planting stick; the next most primitive is the hoe.

There is also the one-shovel plow, drawn by one animal, the in-between-row cultivator that is used extensively in parts of southern United States. The common two-horse cultivator is still extensively used in parts of the United States. Where the yield per acre and the area will permit such investment, the southern states are attempting mechanical cultivation as used in the Corn Belt. Much of the south has a yield of 10 to 15 bushels per acre on the less productive land, and this

limited yield will not permit the use of expensive equipment. This return, however, is important to a man who lives on the land, if he uses part of it for human food.

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CHAPTER XI

WEEDS—PREVALENCE AND METHODS OF CONTROL

The group of weeds included in this chapter is common in areas where corn is grown. Some or all of them are found in every corn field. The chief purpose for the cultivation of corn is to kill weeds.

The weeds in this group were not chosen because of their botanical characteristics. That is to say, they are not here because they are vines, grasses, annuals, or perennials. They are listed because their presence in corn fields requires frequent cultivation. They have a few characteristics in common. They all absorb fertility from the soil and rob the crops of moisture. If any of them start even with or earlier than corn and are not controlled, a reduced corn yield results. Chemicals used as weed spray materials are increasing in use. These are beginning to change cultivation practices.

Canada thistle (*Cirsium arvense*). Canada thistle is a perennial, reproducing by underground rootstalks and seeds. This weed was originally imported from Europe. The plant has somewhat fleshy underground rootstalks which send up new shoots every 8 to 12 inches. In the fall, the plant produces a rosette of basal leaves from 3 to 6 inches long, with wavy, spiny margins. In the spring, a flowering stalk 2 to 4 feet high is produced. The stalk and the leaves have occasional weak spines. A large number of spineless small heads are produced. The plant is dioecious and does not produce seed in all the heads. Sometimes a whole patch will be made up of barren (male) plants. The seeds are a smooth, light to

dark-brown color, oblong, slightly flattened, and slightly curved.

TABLE 10

WEEDS

Common Name	Scientific Name	Duration of Life in Soil (Years)
Perennials		
1. Canada thistle	*Cirsium arvense*	20 or more
2. Quack-grass	*Agropyron repens*	4
3. Hedge bindweed (wild morning-glory)	*Convolvulus sepium*	
4. Horse nettle	*Solanum carolinense*	11 or more
5. European bindweed (creeping Jenny) (wild morning-glory)	*Convolvulus arvensis*	20 or more
Annuals		
1. Foxtail, green	*Setaria viridis*	20 or more
2. Foxtail, yellow	*Setaria glauca*	30 or more
3. Giant prickly foxtail	*Setaria faberii* (Herrm)	Unknown
4. Pennsylvania smart-weed	*Polygonum pennsylvanicum*	20 or more
5. Pigweed	*Amaranthus retroflexus*	40 or more
6. Lamb's-quarters	*Chenopodium album*	40 or more
7. Buttonweed (velvet-leaf)	*Abutilon theophrasti*	60 or more
8. Cocklebur	*Xanthium commune*	Several
9. Russian thistle	*Salsola kali* var. *tenuifolia*	2
10. Barnyard grass	*Echinochloa crusgalli*	5
11. Sunflower	*Helianthus annuus*	2
12. Burning bush, fire-weed, summer cypress	*Kochia scoparia*	Unknown

Canada thistle is a weed that seems to pass from owner to owner when the farm is sold. It can be eradicated by late spring plowing, by cultivating the corn with sweeps, by going through and taking the weeds out of the hills with the hoe, and by going through the field with the hoe at a period of about every ten days or two weeks for the rest of the season. If the infestation has been heavy, a better method is to smother the weed with beans, or with rye following beans, to reduce

the number of plants before the hoe is used. This weed may be sprayed to good advantage in pastures and meadows.

Quack-grass (*Agropyron repens*). Quack-grass is a perennial, reproducing by seeds and underground stems. The slender underground stems may be found from 2 to 12 inches below the surface, producing roots at every joint and capable of complete possession of the land. The plants are from 1 to 3 feet tall. The leaves and stems are a deep green color. The lower dry sheaths and leaves are distinctly hairy. The terminal spikes are from 2 to 4 inches long and have four to seven flowered spikelets. The empty glumes are distinctly five- to eight-lined with short awns or awn points.

In the northern part of the Corn Belt, quack-grass is one of the worst weed competitors against corn. It makes a very tough dense sod and is difficult to eliminate, once it is started in a field. If fields are summer fallowed and plowed two or three times during the summer, a good corn crop is possible the following year, even though the weeds are not entirely eliminated. The spring-tooth harrow is used against this weed during summer fallow season and also just previous to planting corn. If the roots can be allowed to dry above ground, many may die. Spraying with 2,4-D is not satisfactory. Sodium chlorate or Atlacide will kill quack-grass, but such applications make the soil sterile for a while. Two treatments usually are necessary. Either of these sprays will kill growing corn.

Hedge bindweed (wild morning-glory, *Convolvulus sepium*). Hedge bindweed is a perennial, reproducing by seeds and rootstalks. The rootstalks are large and thick and penetrate the ground to great distances. The leaves are large and triangular with the basal lobes pointing out. The flowers are white, about 2 inches across, and borne between two large bracts. Only one flower is produced in a leaf axil. Each large capsule usually produces four seeds which closely resemble cultivated morning-glory seeds.

Botanically, there are several closely related species of morning-glory. It is next to impossible to grow a good corn

crop where morning-glory is abundantly present. If the ground is plowed late in May and planted immediately to an early variety of corn, it is possible to grow a pretty good corn crop in spite of the morning-glory. The weed may be choked with rye, using the method described for eradicating horse nettle. Some farmers eliminate these weeds by fall plowing but this is not always successful. Fall plowing is more successful when July and August are exceedingly dry. Two years out of five in meadow crop or rotation usually does not eliminate morning-glory, but it does permit growing a satisfactory corn crop. If it is possible to use pasture rotation, particularly with hogs in a field where wild morning-glory grows, the morning-glory disappears. If the ground must go into corn, the ground should be cultivated frequently, with sweeps on the cultivator. Some vines will grow in the hills, but a good corn crop is still possible. Repeated spraying with a modern spray is satisfactory.

Horse nettle (*Solanum carolinense*). Horse nettle is a perennial, reproducing by seed and underground rootstalks. Horizontal underground rootstalks are produced, which spread the plant over a large circular area. The plant grows from 6 inches to 2 feet high, branching near the top. The stems and leaf midribs are covered with hairs and yellow spines. The pale-violet or white flowers very closely resemble potato flowers in size and shape. Yellowish orange berries about ½ inch in diameter are produced on a raceme. Each berry contains a juicy pulp and many orange, flat seeds.

Horse nettle is considered in the same class with creeping Jenny, as far as nuisance value is concerned. However, it is easier to eliminate. It is possible to grow a pretty good corn crop in spite of horse nettle, but no efficient farmer enjoys horse nettle. It may be reduced with surface cultivation and a summer fallow program previous to planting the corn. One method of eradication is to allow the weeds to get well started in the spring, plow the ground late, and plant soybeans, using

plenty of seed. When the weeds are in bloom, plow under the beans and horse nettle. Sow rye, using plenty of seed.

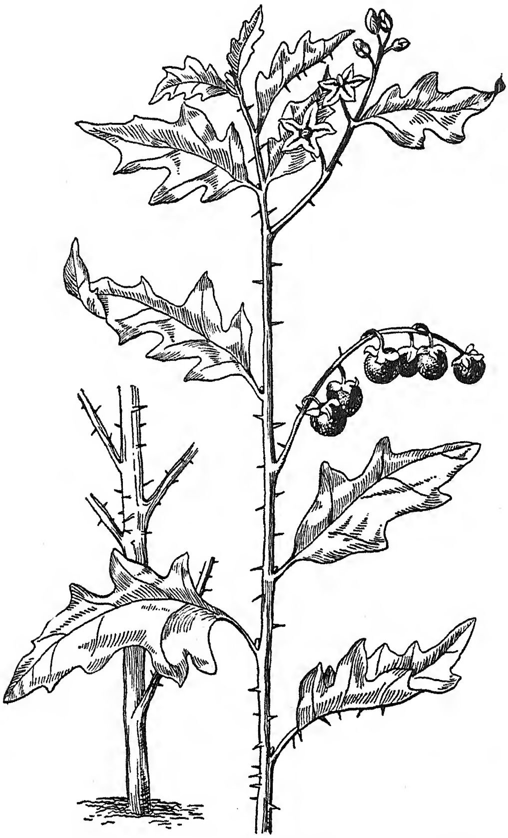

Fig. 26. Horse nettle—*Solanum carolinense.*

Harvest the rye in the usual method and follow with corn. There are other methods of eradication, but this is satisfactory. There will be a few scattered horse nettles that may be sprayed. Horse nettle is more resistant to sprays than are other weeds with wide leaves.

European bindweed (creeping Jenny, *Convolvulus arvensis*). Bindweed is a perennial, imported from Europe, reproducing by seed and underground rootstalks. The plant produces

FIG. 27. Creeping Jenny—*Convolvulus arvenis.*

underground rootstalks which spread in every direction from the plant. These rootstalks, which travel horizontally under the ground for 12 to 30 inches, send up a shoot which roots readily. Several rootstalks are then sent out in all directions, and the process is repeated. The roots that are sent down sometimes go as deep as 25 or 30 feet. The stems are slender,

have a prostrate or twining habit of growth, and range from 2 to 7 feet in length. The leaves are ovate oblong, with acute basal lobes. The flowers are pink or white, funnel shaped, and about 1 inch across. They are usually borne single in the leaf axils. The capsules bear from one to four dark-brown, coarsely roughened seeds which usually have two flattened sides and one convex side.

Creeping Jenny is one of the weeds that passes along from owner to owner when the farm changes hands. Most corn growers consider this weed almost as persistent as taxes. There is no use trying to eliminate this weed when cultivating the crop. To grow corn on ground infested with creeping Jenny, eliminate the weed and then grow corn. If this weed is sprayed according to the directions, great progress may be made against it. The weed must be sprayed as often as it shows much growth above ground. Creeping Jenny succumbs to repeated spraying with 2,4-D. However, using 2,4-D for cropping season does not insure complete eradication of the weed.

Green foxtail (*Setaria viridis*). Green foxtail is an annual, reproducing only by seed. It is a native of Europe. The plant grows from 1 to 3 feet tall, has dark-green, rough-margined leaves, and a head 2 to 4 inches long, which is densely covered with green bristles. The seeds are nearly oval, slightly flattened on one side. They are usually green in color, but they may be straw, brown, or nearly black.

Yellow foxtail (*Setaria glauca*). Yellow foxtail is an annual, reproducing only by seed. The plant resembles green foxtail, but it usually grows taller and coarser. The head is a yellowish brown color and is not so bristly as the head of green foxtail; the seed is much larger. Yellow foxtail matures later than green foxtail, but it nevertheless produces enormous amounts of seed.

Giant prickly foxtail (*Setaria faberii*). This comparatively new weed may reach a height of 6 or more feet on fertile cornfield soil. The easiest way to recognize this weed is by the

roughly pubescent upper surface of the leaves, which are covered with rather stiff sharp projections which are supposed to be soft in most species of such plants. On *Setaria faberii*, these are almost stiff thorns. The weed is much bigger than our common foxtails. The spikelets that bear the seed are from 2½ to 3 inches long. It seems to have been introduced from China and has appeared in New Jersey, Pennsylvania, and south along the Atlantic Coast, and also in Nebraska, Missouri, and western Iowa. This weed is likely to be a very serious economic pest for corn growers.

Foxtails, green, yellow, bristly, or giant, all belong to the genus *Setaria*. All have similar growth habits and all must be controlled in order to grow a corn crop. It is not uncommon to have early corn fields that become so "grassy" with foxtails that it is necessary to rework the ground and replant the corn. No other weed in the central Corn Belt has been responsible for as much corn replanting. Foxtail begins growing in the spring before it is warm enough for the corn to sprout. Foxtail grows when the weather is too cold, when it is too wet, or when it is dry. If the weather is cold the foxtail grows faster than the corn. Foxtail will grow where the moisture in the soil is too high for good corn-growing conditions. It grows again in the fall after the corn is ripe. This weed starts with a little spear, then two, then three; then it stools out, and each succeeding day it becomes more difficult to destroy. A harrow or weeder will destroy the weed when it is ¼ to 1 inch high. These same tools are useless when the weed is 1½ inches or more in height. Therefore the corn must be cultivated while small. The dirt is moved up close to the corn in an effort to cover all the weeds and let the corn still remain above the new dirt. By the time the corn is ready to plow the second time, there may be a new crop of foxtail from the seed that did not germinate previously.

Clean and continuous cultivation until the corn shades the ground is necessary to keep down foxtail. A crop rotation that includes alfalfa for two or more years aids tremendously

in the prevention of foxtail. Not all the seed lives long in the soil. Where alfalfa or other meadow crops have been grown, the following corn crops may be comparatively free of foxtail. The same may be said of brome grass and bluegrass, in their ability to reduce the amount of foxtail in the corn crop that follows.

Pennsylvania smartweed (*Polygonum pennsylvanicum*). Pennsylvania smartweed is an annual, reproducing only by seed. The plant grows from 2 to 5 feet high, branching at the nodes. It has lance-shaped leaves, 3 to 10 inches long, and bright pink or rose-colored flowers. The smooth seeds are shiny black, flattened, almost circular, but sometimes slightly triangular. Pennsylvania smartweed seed matures during most of the summer.

Pennsylvania smartweed is one specific weed. There is a large group of smartweeds which grow very much alike. They are widely distributed in the Corn Belt and are a great nuisance. They start in the spring, the same time as foxtail, but they do not grow quite so readily as foxtail in cold weather. They do offer a real problem where the soil is a little on the moist side for proper farming. While the weeds are small, they can be controlled with the weeder or harrow when the ground is dry on top. If they are in the row, they stay in the corn when the corn is cultivated. In checked corn they stay in the hill. The use of sweeps is a great aid in controlling smartweeds. Sweeps should be used just ahead of the corn planter when the weeds are not large. Smartweeds are greatly reduced in number within a field if alfalfa appears in the rotation. They are also considerably reduced if the land is used for rotation pasture, including hogs, cattle, or sheep.

Pigweed (*Amaranthus retroflexus*). Pigweed is an annual, more or less pubescent. It grows 3 to 5 feet tall. The leaves are mostly ovate with irregular edges. Flowers appear in thick spikes crowded together in stiff bunches on or near the upper end of all branches.

The weed is distributed through all areas that grow corn. The seed is somewhat smaller than clover seed and may be taken from one farm to another along with the clover seed. Pigweed will not survive clean cultivation. Young pigweed is relished by livestock. It succumbs to sprays that are recommended for wide-leaf weeds, similar to some other rather rapidly growing weeds that may establish themselves in corn hills or in drilled corn rows where they cannot be destroyed by cultivation. Pigweeds also make seed even though they do not come through the ground until early July or later. In dry soil the seed lives an exceedingly long time. In moist soil it does not survive more than about five years.

Lamb's-quarters (*Chenopodium album*). Lamb's-quarters is an annual, reproducing only by seed. It forms a slender stalk which grows from 1 to 6 feet high, depending upon growing conditions. The stem is much branched and usually ridged and grooved. The leaves are 1 to 3 inches long, somewhat goosefoot shaped, and generally covered with a white mealy substance. The seeds are oval and flattened with convex sides and a dull to shiny black color. A dull gray hull usually covers all the seed except a tiny spot in the center.

Lamb's-quarters does not do so well where the ground is too moist for good corn growing. It is very vigorous where the nitrogen content in the soil is high. The seeds live in the ground for a considerable length of time, and it is almost impossible to control the weed if the rotation does not include a meadow for hay or rotation pasture. Like the buttonweed it may be controlled by pulling. When tender, lamb's-quarters is relished by livestock. Lamb's-quarters offers a cultivation problem similar to that of smartweed, buttonweed, and pigweed.

Buttonweed (velvetleaf, *Abutilon theophrasti*). Buttonweed is an annual, reproducing only by seed. It is an ancient weed and native of Asia. The heart-shaped leaves are from 2 to 5 inches wide and covered on both sides with thick hairs, which give the leaves a velvety appearance. The yellow flow-

ers are about 1 inch across and are borne in the axils of the leaves. The broad, conspicuous seed pods contain numerous dull, gray seeds that are flattened and have notches at one end.

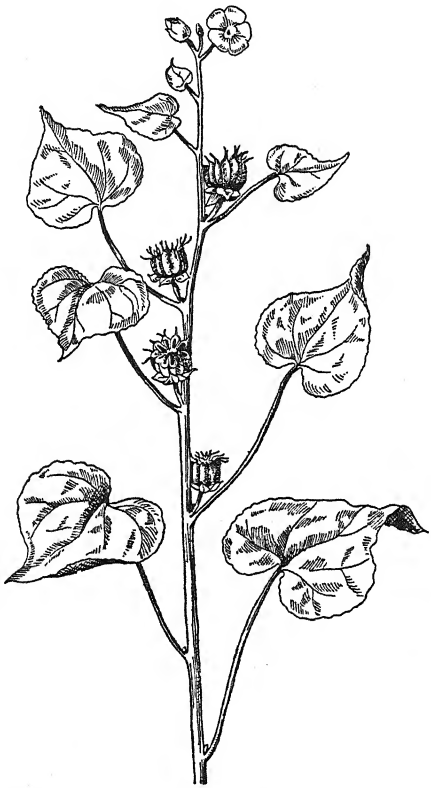

Fig. 28. Buttonweed—*Abutilon theophrasti.*

This weed seems to live indefinitely in the soil. Records show that this seed can lay dormant in the soil as long as 60 years and still germinate. Once this weed is established on a farm, complete elimination is next to impossible because of the longevity of the seed in the ground. This seed does not

germinate unless it is 1 inch or less from the top of the ground and the soil is exposed to the sun.

Most botanists do not consider buttonweed an exceedingly serious pest, yet it causes considerable damage in rich corn fields where it is well established. This weed may be destroyed when small by the harrow or weeder. It does not make the same kind of vigorous growth in cold or wet weather as does foxtail. With no more than ordinary cultivation of corn, this weed may be controlled during the cultivating season. There will be a few plants that escape cultivation right in the hill of corn. These may be pulled, and after they are dropped on the ground they will not sprout. After the corn has been laid by, any portion of the ground exposed to the sun will grow buttonweeds if the seeds are in the ground. The recent tremendous increase in the growing of soybeans in the Corn Belt has added greatly to field infestation of buttonweeds. Soybeans are really a "nurse crop" for buttonweeds. Buttonweeds start to grow as soon as the soybeans do, and they soon become taller than the beans. In the early stages of growth their mass appearance is quite similar to that of soybeans, and a mass infestation gets the upper hand before the farmer realizes that anything is wrong. They grow vigorously and each plant has numerous seeds. These seeds lodge in various farm machinery, particularly in corn pickers, and are scattered from field to field and farm to farm. The weed can be controlled and reduced to the minimum if all mature weeds are pulled every year before the seed gets hard. In fall plowing, if these weeds are plowed under before the seed pods open, very few of the seeds will live indefinitely in the soil.

Cocklebur (*Xanthium commune*). Cocklebur is an annual, reproducing only by seed. The plant grows from 1 to 3 feet tall, is widely branching and spreading, and has a rough thick stem with distinct brown spots. The leaves are rough on both sides. Cocklebur produces monoecious flowers. The staminate flowers are produced on the ends of branches, and the pistillates are produced in the axils of the leaves. The

burs are about 1 inch long, brown in color, and covered with coarse hooked spines. Each bur contains two seeds, which may remain in the bur for several years before growing. Under favorable growing conditions, one of these seeds may sprout one year and the other the following year.

This weed is not particularly difficult to eliminate. In many ways it does not grow so rank as buttonweed or lamb's-quarters, and it does not start so early in the spring as sweet clover. If there are two years in meadow between corn crops, the weed will disappear, provided that the fence rows are thoroughly mowed both years and that there are no burs carried in from neighboring fields. The burs start to grow in small grain fields, and after the small grain has been harvested several burs will grow on each small plant. Mowing or early fall plowing of stubble ground will reduce cocklebur in the following corn crop. It submits rather readily to cultivation. However, it does stay in the hill of corn or row of drilled corn. It is carried about from place to place by livestock, dogs, and rabbits, and even on the clothing of the operators. Young plants 1 or 2 inches high are poisonous to hogs. Spraying with 2,4-D is very helpful.

Russian thistle (*Salsola kali* var. *tenuifolia*). Russian thistle is an annual, reproducing only by seed. It grows from 1 to 4 feet high, branching profusely and forming a dense, nearly round bush. The leaves are round and reduced almost to spines. The small green or pink flowers are borne in the axils of the leaves and stems. The seeds are small and conical with a flat circular base. Upon removal of the papery gray outer seed coat, a yellow coiled embryo having the appearance of a snail shell may be seen.

The Russian thistle is prevalent in the western portion of the United States, particularly the portion that does not get too much moisture. It is readily controlled by prompt and complete cultivation. However, such cultivation is not always possible. Any weeds that remain to mature produce an

abundance of seed, and the great number of plants that come from seed each year make the weed a problem.

Barnyard grass (*Echinochloa crusgalli*). Barnyard grass is an annual, reproducing only by seed. It prefers a rich moist soil and grows in such places so profusely that it is a troublesome weed. The plant has a spreading habit of growth, with stems from 1 to 5 feet tall. The leaves and sheaths are usually smooth but may have rough edges. The heads are from 3 to 10 inches long with short branches at the lower portion. The shiny, yellowish gray to brown seeds are nearly oval, with one side rounded and the other flat.

In parts of Iowa this weed is called bull grass. It is similar to foxtail, although not nearly so persistent, and it grows better where the nitrogen content is high in the soil. Abundant moisture is also necessary for vigorous growth. Where the soil is thin and the moisture is not plentiful, the weed is not particularly hard to manage. It requires about the same treatment as foxtail. It is a more vigorous grower than foxtail, except on thin land. Clean cultivation and rotation of crops are desirable. Livestock relish the green growing plants, and they are higher in feeding value than most weeds.

Sunflower (*Helianthus annuus*). The sunflower is an annual, reproducing only by seed. It is found in cultivated fields, along fence rows and roadsides, and in waste places. The plant grows from 4 to 10 feet high and will branch a great deal if it is not growing in a thick stand. The stems and leaves are rough and hairy. The heads have bright yellow ray flowers and brown disk centers. The seeds or achenes are ovate to wedge-shaped, flattened, and a gray or brown color with lighter gray spots or stripes.

The sunflower is a weed that interferes with corn growing in the southwest portion of the corn-growing area, particularly Kansas, Nebraska, Iowa, Oklahoma, and Texas. The seeds do not live very long in the ground, and the young weeds succumb rather readily to proper cultivation. The use of sweeps on cultivators has aided materially in controlling this weed. If

it is possible to prevent the weed from going to seed, it may be pretty nearly eliminated in two or three years. The difficulty is that it gets in the corn row, resisting destruction by cultivation methods. It does succumb to 2,4-D spray.

Burning bush, fireweed, summer cypress (*Kochia scoparia*). Kochia is an annual, reproducing only by seed. It is found growing in waste places along fence rows, in stubble fields, alfalfa fields, and gardens. The plant grows from 2 to 7 feet high in an erect bushy form, branching profusely from a central stem. The small linear leaves are attached directly to the stem. Inconspicuous flowers are borne in the axils of the upper leaves. The seeds are a pale grayish black color with yellow markings and a flattened triangular shape. Seeds of kochia are generally found in alfalfa and clover seed. Kochia is fast becoming a weed of wide economic importance and has become one of the conspicuous weeds in the western Corn Belt. It produces an abundance of seed. The plants have persistent growing habits. A good stand of spring grain will suppress kochia, but a thin stand will be overrun by it and should be mowed or plowed up. Old matured plants should be burned before the wind moves the plants and scatters the seed. Care should be taken to plant only crop seed that is free from kochia. In the last ten years kochia has spread rapidly over the whole state of Nebraska and has entered adjoining states.

WEED SPRAYS

Science has recently produced some new weed-killing chemicals. They look very promising for some purposes. One of the most important is called 2,4-D (2,4-dichlorophenoxyacetic acid) which can be applied without any fear of poisoning, of hurting grass or the soil, or of poisoning the livestock which may eat sprayed plants. Part of the result may be overstimulating the growth of the sprayed plant.

So far as farmers are concerned, more must be learned about 2,4-D to determine how good a job it will do on such deep-

rooted perennials as Canada thistle, bindweed, horse nettle, and the like. So far, two or more sprayings are needed to kill Canada thistle. It has seemed to do a better killing job with bindweed.

The concentration of 2,4-D used on weeds other than grassy does not injure grassy weeds. Therefore it cannot be used to kill quack-grass, foxtails, and barnyard grass.

Another chemical compound is sodium dinitro-orthocresylate, with a trade name of Sinox.

Not all weed problems are going to vanish with spraying, but these chemicals do provide a weapon to help eradicate some of the plant pests with less labor and a smaller cost than before.

The following weeds submit to sodium chlorate, ammonium trichloroacetate sprays, but not to 2,4-D:

Quack-grass
Foxtails
Barnyard grass

The following weeds are controlled in part, but not altogether, by the use of 2,4-D or other newer sprays:

Canadian thistle	Russian thistle
Wild morning-glory	Bindweed
Creeping Jenny	Sunflower
Pigweed	Buttonweed
Lamb's-quarters	Burning bush
Cocklebur	

It is well to bear in mind that 2,4-D has a measurably injurious effect on corn if it is used in too high a concentration (more than ½ pound per acre). There is a balance between damage to the crop and the effectiveness of the spray which must be carefully worked out to determine concentration of spray and time of application.

Spraying with any chemical is not cheap per acre, and the cost should be estimated before the spraying program is at-

tempted. All the recommendations of the experiment stations and the manufacturers about how to mix the concentrated materials should be followed accurately. Added precaution against fire should be taken for sodium chlorate. When this material dries it is almost as effective a fire starter as the head of an ordinary match. Sodium chlorate is poisonous to livestock if it is consumed in great quantities on sprayed weeds.

Recent recommendations indicate that a highly concentrated liquid spray (a fog) requiring a minimum amount of moisture is the best to use. In addition, some experiments indicate that dusting various weeds may be effective. There is, however, no immediate prospect of controlling the weeds mentioned in this chapter without the use of crop rotations and clean cultivation. When growing a corn crop, it is easier to control, reduce, or eliminate the weeds during the season previous to the corn crop than after the corn is planted.

Pre-emergence spray is a term used to designate a spraying practice. The spray material is applied to the ground after the corn is planted before it comes up. This practice is receiving much experimental attention, particularly with regard to the control of weeds in the grass family.

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CHAPTER XII

CONTROLLING INSECTS, DISEASES, AND OTHER PESTS

INSECTS OF CORN

Insects that attack corn are numerous, but most of them do not cause serious damage. Occasionally local attacks are severe, and the entire crop of a community may be destroyed as a result of the work of a particular insect. Control measures, to be practical, should be simple, cheap, and easily applied.

Most common corn insects have four stages in their life history, which may last a part of a year, one year, or several years. The four stages are the egg, the larva, the pupa, and the adult stages. An adult insect usually deposits several hundred eggs, and its function in life is completed. The eggs, as a rule, hatch out quickly into the larval or worm stage. After the worm finishes feeding, it enters the pupal or resting stage. From the pupa emerges the adult as the butterfly does from the cocoon. Some insects, such as the aphid, bear live young.

The description of the insect, its life history, the character of the damage done, and the control measures are given for the important insects of corn in the Corn Belt. The insects are divided into four classes: those that work primarily on (1) roots, (2) stalks and leaves, (3) the entire plant, or (4) stored grain.

Insects That Work on Roots

Wireworm. The common wireworm is reddish brown in color, hard and rather shiny in appearance, cylindrical in

shape, and an inch or more in length when full grown. The adults are boat-shaped fellows, ½ to ¾ inch long and brown or black in color. They are known as "click beetles" or "snapping beetles" from the snapping noise they make when on their backs.

TABLE 11

INSECTS THAT WORK ON ROOTS

Wireworm	*Melanotus cribulosus* (LeConte)
Corn root aphid	*Anuraphis maidi-radicis* (Forbes)
Northern corn rootworm	*Diabrotica longicornis* (Say)
Southern corn rootworm	*Diabrotica duodecimpunctata* (Fabricicus)
White grub	*Phyllophaga rugosa* (Melsheimer)

INSECTS THAT WORK ON STALKS AND LEAVES

Cutworms, spotted	*Agrotis c-nigrum* (Linné)
black	*Agrotis ypsilon* (Rottemburg)
glassy	*Crymodes devastator* (Brace)
Chinch bug	*Blissus leucopterus* (Say)
Hairy chinch bug	*Blissus hirtus* (Montandon)
	Blissus iowensis (André)
Maize billbug	*Calendra maidis* (Chittenden)
Armyworm	*Cirphis unipuncta* (Haworth)
Grasshopper	*Melanoplus femur-rubrum* (DeGeer)
	Melanoplus mexicanus spretus (Walsh)
	Camnula pellucida (Scudder)
Corn earworm	*Heliothis armigera* (Hubner)
Stalk borer	*Papaipema nebris* (Guenee)

INSECTS THAT WORK ON THE ENTIRE PLANT

European corn borer	*Pyrausta nubilalis* (Hubner)
Southern cornstalk borer	*Diatraea crambidoides* (Grote)

INSECTS THAT WORK ON STORED CORN

Angoumois grain moth	*Sitotroga cerealella* (Olivier)
Seed-corn maggot	*Hylemyia cilicrura* (Rondani)

The wireworm usually changes to the pupal stage in July or in early August in the Corn Belt. Climate has some effect on date of change. Only two or three weeks are spent in this

stage before the worm changes to a beetle. The beetle, however, spends the winter in the pupal cell and comes out the next spring. It deposits its eggs in the soil. The larvae hatch

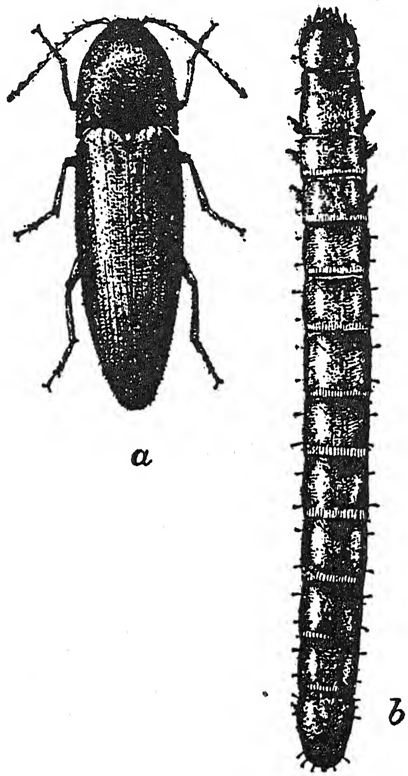

FIG. 29. (*a*) Wireworm beetle or click beetle. (*b*) Wireworm (much enlarged). The full-grown wireworm is only about 1½ inches long.

out in a few days and begin feeding. The corn wireworm may spend as long as five years in the soil, whereas the wheat wireworm spends only three.

The failure of seed to sprout or the withering of corn plants at 2 feet or less in height often indicates wireworm attack. If

the affected field has been in grass a year or so previous, the injury is most likely to be caused by wireworms. The larvae do not cause any visible injury to grass. However, when grass land is put into corn, the wireworms concentrate on the hills of the planted grain and cause much damage. They feed first on the seed itself, later on the roots. Wireworms are difficult to control because (1) they work underground, (2) they cling to life, and (3) there are several injurious species of wireworms requiring different methods of control. Many attempts have been made to find a practical control for the wireworm, none of which has been entirely successful. Fields that are in regular rotation of corn, two out of five or one out of three years, are more satisfactory than fields in longer rotations. There have been several experiments carried on in an effort to control wireworms by treating the soil or the seed with various chemicals. Control has not been very successful, although some of the newer organic insecticides offer great promise.

Root aphids. The corn root aphid or root louse is a tiny blue-green insect. The root lice which hatch from the eggs in the spring are all females. During the summer they produce ten to twenty generations of live young. These females are found throughout the spring and summer, and the males do not appear until fall. Root lice multiply very rapidly and cause much damage to growing plants. Most of them are wingless, but occasionally winged forms are found. In the fall, both males and females appear. Mating takes place and the females then deposit eggs instead of producing young. These eggs are taken up by little brown ants, which care for them in their nests during the winter. The root lice are very well cared for by the ants, because the aphid excretes a sweet substance, "honey-dew," which the ants like.

The presence of the corn root aphid in great numbers in a field of growing corn is usually shown by (1) dwarfing of the plants and a yellowing or reddening of the leaves, (2) numerous ant hills near affected stalks, and (3) the presence of many

lice on the main roots. The tiny lice suck the juices from the roots, thereby weakening the growth and reducing the yield.

Crop rotation is the most effective measure against the root aphid, although it feeds on plants other than corn. Where crop rotation with only one or two consecutive crops of corn is practiced, little injury occurs. With the exception of cotton in the south, the other crops grown are not much affected, as corn is the favorite food of the corn aphid. If rotation is not practical, deep and frequent cultivation early in the season may help. This deep and frequent cultivation discourages the ants. If the edges of the fields are watched carefully the migration of ants may be seen out of the fields. No method of treating seed corn against corn root aphid has proved successful.

Corn rootworm. The rootworms are small, slender, white grubs, about ½ inch long when full grown. The northern form of the rootworm in its adult stage is a plain grass-green beetle, about ⅕ inch long. The adult beetle of the southern rootworm is green, with twelve black spots on its back. It is also somewhat larger than the northern rootworm beetle, measuring nearly ¼ inch long.

In the fall, the beetle of the northern form may be seen on the silk of corn and on the flowers of the golden rod. The beetles deposit their eggs in the soil near the stalks of corn. The next spring these eggs hatch out early. The young rootworms begin to attack the corn almost as soon as it is out of the ground. Throughout the summer, the larvae work on the roots. When the larvae mature in July and August, they change to the pupal stage, in which they spend only a short time. The plain green beetle emerges from this pupa, and the life history is repeated with one generation per year.

The black-spotted beetles of the southern corn rootworm are found not only in the fall but all through the season, from early spring onward. The life history of the southern corn rootworm is similar to that of the northern form, except that it is passed through in a much shorter time. Some of the adult beetles

live through the winter by hibernation. Adults, often aided by prevailing winds, fly north each spring. Two generations per season seem to be possible for the southern rootworm under favorable conditions. Special planting dates are recommended for planting corn in the southern United States. These dates may be obtained from the local county extension director or the nearest experiment station. These same sources of in-

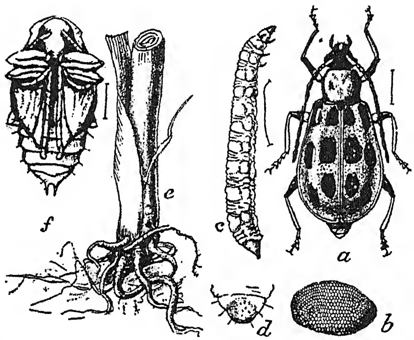

FIG. 30. (*a*) Corn rootworm beetle. (*b*) Egg. (*c*) Corn rootworm whose feeding causes most of damage. (*e*) Base of young corn plant with entrance hole of rootworm. (*f*) Pupa or resting stage that precedes the beetle. (Enlarged.)

formation will furnish recommendations as to the use of hybrid corn that is adapted to that particular area. Another recommendation is to plant about twice as many kernels per acre as is needed for the final stand on the lower lands. Judicious crop rotation is an aid in reducing the damage caused by southern rootworms.

Corn is the only food plant of the northern rootworm. On the other hand, the southern rootworms have been found in wheat, rye, millet, and over two hundred other crop plants. It is known, therefore, by many other names, including the spotted cucumber beetle and the budworm. The northern form does more injury to the corn in the north. The withering of young plants and the blowing over of the stalks may be due to

the rootworm. A careful investigation of the field in which the corn has blown over will often reveal the presence of the corn rootworm in larva form and also in beetle form.

Plain green or the black-spotted beetles are seen in very large numbers feeding on the silks of the corn in August. These beetles are a nuisance to the corn breeder. They devour pollen and cut the silks. When the pollen and silks are disturbed, hand pollenation is more difficult. Fields that are infested with northern corn rootworms should not be planted to corn the following year since the worms do not thrive without corn as a host. Crop rotation is an effective control. Corn rootworms are considered among the most serious insect pests of corn. Economically they are exceedingly important. The yield in a field infested with corn rootworms may be greatly reduced in comparison with a similar field not infested. Corn breeders are making some progress in producing hybrids that grow new sprouts on roots that have been cut by insects. These new roots help provide nourishment and strength to the corn plant following severe root damage. The Nebraska Experiment Station has been using benzene hexachloride, gamma isomer, commonly called 6–6–6. The results of field tests show that it is effective in reducing damage from rootworms on corn. The chemical is not recommended for direct application to the seed. It has been applied as a side dressing at the time of planting or broadcast after planting.

White grub. The grub is a large, white larva with a reddish brown head. It is similar to the grub found in manure piles, which, however, is not injurious to corn. The parent form of the white grub is the common May beetle or June bug, the large, black or brownish beetle which flies to the lights in May and early June. In the Corn Belt proper, it appears somewhat earlier in a warm spring.

The beetles hide in the soil all day. After sundown they feed on the leaves of trees, often doing considerable damage. They deposit their eggs in rather compact soil, usually sod ground, during June. These eggs hatch and the young grubs

begin to feed on the roots of the grass that summer. Grubs of most species do not become full grown for two years, and even then they remain in the soil for a third winter, emerging as beetles nearly three years after the eggs were deposited. A generalized life history is as follows:

First year. In May the beetles emerge from the soil, feed, and deposit eggs. The larvae hatch, begin to feed, and winter over in the soil.

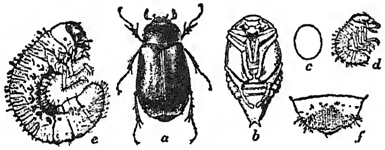

FIG. 31. (*a*) June bug. (*d*) Half-grown grub at stage when it does the most damage to corn. (*e*) Full-grown white grub ready to pupate. (Reduced.)

Second year. The larvae feed during the season. Most damage to crops is caused this year. The larvae winter over in the soil, practically full grown.

Third year. The larvae feed early in the season, pupate in June or July, and change to beetles a few weeks later. The beetles stay in the soil over the winter. A few common species complete their life cycle in two years.

The presence of the white grub is indicated by (1) dwarfing of the plant, (2) killing of the plant in any stage of growth, (3) a weak root system, and (4) falling of the stalk. The grubs are not known to infest such crops as clover, alfalfa, or buckwheat; these may be safely grown on sod in a "grub year." Small grains are attacked by the grubs, but to a less extent than corn or potatoes.

Under certain conditions, grubs may be controlled by proper rotation, particularly in a district known to be badly infested. Grubs are usually abundant near wooded areas. When grubs are expected in any particular year, corn should not be planted

on sod. It may safely follow a cultivated crop. By referring to the generalized life cycle, one may determine when to expect damage by grubs. For instance, if the beetles are exceptionally abundant one year, a large number of grubs may be expected the next year. In any given locality, the grubs are likely to be numerous at three-year intervals. For example, the worst outbreaks during the past few years were in 1939, 1942, and 1945.

If the two-year-old grubs are damaging corn, there is no practical measure to get rid of them at once without injuring the crop. However, such measures as fall plowing, rotation, and turning hogs in on grub-infested land may partially prevent further injury. Hogs turned onto infested fields by the middle of October, before the grubs go deep, will rapidly clear out most of them. The only objecton to turning in hogs is that occasionally they become infested with the thorn-headed worm, which is a parasite of both hogs and white grubs. Because the grubs go deeper into the soil for the winter, early fall plowing is of some value as it brings the grubs to the surface and crushes many of them.

Insects That Work on Stalks and Leaves

Cutworm. Full-grown cutworms are about 1½ inches long, usually dull in color. Rarely do they have the distinctive markings or stripes found on the variegated cutworm which attacks clover. Late in June or early in July the mature larva forms a loose cell in the soil, changes to the pupal stage, and a few days later to the adult or moth stage. Moths of the various species are much alike. All are dull in appearance and brown or gray in color, with the hind wings lighter than the fore wings.

The moths deposit eggs in the grass lands late in the season. The larvae hatch the same fall and spend the winter in the soil, partly grown. Consequently, they are of good size by the time the young corn plants are pushing their way through

the ground. Except in the south, there is usually only one generation each year. A few important species pupate in the fall.

The cutting off of the young cornstalk at the base of the plant, at or just below the surface of the soil, is the work of cutworms. Usually, the worm responsible for the damage may be found in the soil near the plant attacked. Cutworms seldom damage corn until it comes up.

If cutworms are present in a corn field, the only two measures to be taken are replanting and poisoning. Replanting should be delayed until damage by the insects has practically ceased. Although the cutworm pupates in late June, it usually does very little severe damage after warm weather comes on in early June. One or more hot days when the humidity is high usually stops any damage from cutworms. Poison bait made as follows is effective:

Bran or mixed bran and sawdust	100 pounds
Cheap molasses	1 gallon
Water	10 gallons
White arsenic *or* Paris green	4 to 6 pounds

or

Liquid sodium arsenite (4 pounds to the gallon)	2 quarts

Scattered over a 10-acre corn field, this bait attracts the cutworms, which feed on it and are killed. Results are sometimes good, but occasionally this method seems to be worthless.

Early fall plowing of grass land to be planted in corn the next year is a mildly preventive measure. This plowing buries the eggs or young larvae so that they cannot live through the winter. Close fall pasturing of such land is also beneficial. Extra work in the preparation of the seed bed, particularly with the disk, aids in destroying larvae.

Chinch bug. Young chinch bugs are pale yellow at first, changing to pink, then red, and later black. At first, there are no traces of wings, but in the later stages wing pads appear.

The adult form of the chinch bug is about $\frac{1}{5}$ inch long, black in color, with whitish wings. These wings cross on the back of the insect, forming an X-shaped mark. Chinch bugs shed their skins five times; after the last moult they are full grown.

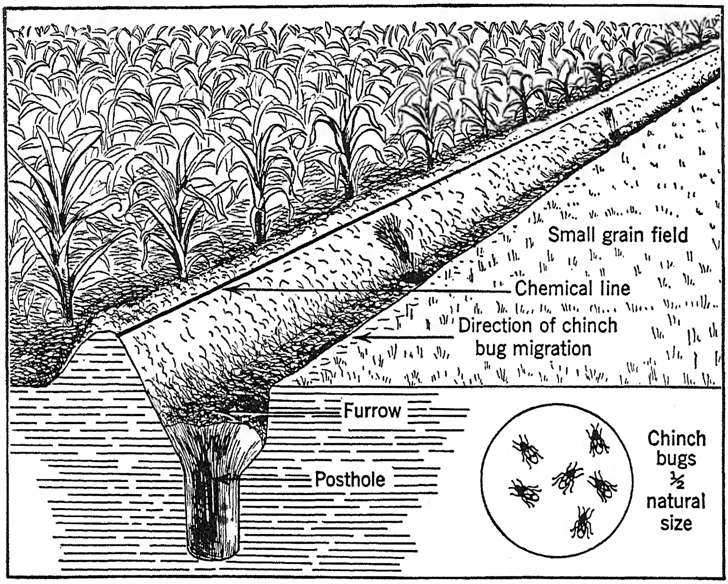

FIG. 32. Drawing of a barrier to prevent chinch bugs from entering a corn field from a small-grain field. A fine dust mulch is provided on the outside of the chemical line. Post holes at intervals are supplied with a limited amount of creosote. The bugs travel along the ditch and are killed in the creosote.

They feed by driving their beaks into the plant tissues and sucking the juices.

During the winter, chinch bugs hibernate in clumps of grass and along fences and hedge rows. In April or May they go to the fields of small grain, which offer food at that time. They soon deposit their eggs, and their young feed on the growing grain. At small-grain harvest most of the bugs of

the preceding year are dead and the wings of the young ones usually have not developed. The bugs seek green food, and since they are unable to fly they crawl from one field to another. Growing corn at this time is especially tempting to the partly grown chinch bug, and the object of control measures is to keep the bugs out of the corn. Chinch bugs mature in the corn field in July and deposit eggs for a second generation. They grow rapidly and feed on the corn. In September, the second generation matures and spends the winter as adults. Part of a third generation is produced in the more southern parts where the insects are found.

Between 1900 and 1923 most chinch bug damage was to corn south of the southern Iowa line. Back in 1887, however, chinch bug injury was noticeable in three-fourths of the counties of Iowa; a similar invasion began in 1933, becoming most serious in 1934, 1935, 1936, and 1937. Damage to corn occurs, for the most part, in midsummer, when the growing bugs pass from ripening wheat to corn. However, it does not necessarily follow that the chinch bug will not become dangerous in localities where no wheat is grown.

In general, methods for controlling the chinch bug are (1) cleaning all rubbish in waste places and (2) placing barriers around fields.

As small-grain harvest in an infested field draws near, measures should be taken to prevent the insects from entering the corn fields. This is best done by making barrier lines of some chemical, such as creosote, around the infested field. Creosote is effective because of its repellent odor. The strip of oil should be ½ inch thick or more. To be most effective creosote lines should be placed just below the top of the sloping sides of a furrow thrown toward the corn. Post holes about 2 feet deep should be dug at intervals of about 20 feet along the barrier line in the bottom of the furrow. A little kerosene poured into these holes will kill the bugs that collect. These barriers must be kept freshened.

Strips of creosoted building paper, about 6 inches wide, set on edge in the soil, were successfully used during the great outbreak of 1934 to 1937. The paper barrier has the advantage of remaining effective in windy weather when blown soil often forms bridges across the plain creosote line. More recently, barrier lines of dinitro dusts applied with a tennis court marker have given good results.

When the bugs are concentrated on a few rows in a corn field, spraying with nicotine sulfate, or dusting with DDT, benzene hexachloride, chlorodane, sabadilla, or other insecticides is practical.

The natural insect enemies of the chinch bug are not numerous nor do they thrive in hot, dry weather. On the other hand, chinch bugs are the most numerous and thrive best under these conditions. Weather more than any other factor regulates the number and extent of chinch bug attacks. Between 1931 and 1937 damage from the chinch bug reached as far north as northern Iowa.

Some hybrids are more tolerant than others to chinch bug damage. One difficulty the corn breeder must face is that chinch bugs do not give opportunity for experiment every year. Chinch bugs require a dry spring in order to multiply into great numbers. High humidity and high temperature develop certain parasitic molds which attack the young chinch bugs and prevent development. Also, chinch bugs move in the direction of prevailing winds in the spring. They are dry hot-weather insects. Small corn, such as inbreds in a breeding plot, is particularly susceptible to the bugs.

The state experiment stations have information early in the season, showing prospective chinch bug population. It is always well to keep informed about predictions of their invasion.

Maize billbug. There are several kinds of billbugs. Most of them are black or brown in color. All are beetles with hard backs and long snouts which make holes in the leaf blades of corn. In the grub stage, the corn billbugs feed on the roots

of certain sedges and grasses. One of the most common billbugs feeds on timothy roots.

In general, the insects spend the winter as beetles which work on the young corn plants in the late spring. In the early summer, the beetles deposit their eggs on timothy, corn, and other grasses. The eggs hatch and the young grubs feed on the grass roots until early fall. The grubs then enter the pupal stage for a short period before they appear as adult beetles.

Tender leaves marked by rows of holes cut across the blade indicate the work of the corn billbug. The injury occurs when the plant is a few inches high and the leaf blade is still within the sheath of the cornstalk. The holes do not become conspicuous until the blade has grown out. Since the blade is curled up within the leaf sheath, one hole made in the leaf sheath means six or eight holes in the curled leaf blade. This damage to the corn plant may offer an opportunity for attack by certain corn diseases. Corn planted on timothy sod or on land on which sedges are present and which has been infested with these grubs is likely to be damaged, especially if the sod has been turned under in the spring.

Early fall or summer plowing of sod lands which are infested with these grubs greatly reduces the injury if corn is to be put in the field the following year. The stirring of the soil disturbs the insects so that they are unable to survive the winter.

Armyworm. The armyworm resembles the cutworm. The color varies from yellow to brown or black. There are three stripes, a middle black one and upper and lower yellowish ones, on each side. The worm pupates in the soil. The pupa gives rise in ten to twenty days to a moth. The moth is a night-flying insect and is often attracted in large numbers to light. The fore wings of the moth are yellowish brown in color and are marked with a small white speck near their center.

Each female moth is capable of laying about 700 eggs. These eggs hatch into small green worms in about eight to twelve days. The young worms eat but little and feed close to the ground. They may be numerous and still escape detection. The worms are nearly fully grown before injury becomes serious. Three to five weeks are required for full growth. The worms then are 1½ inches long and ⅛ inch wide.

Although the armyworms prefer to breed and feed in grass or small grain growing in low and moist parts of fields, they become so abundant and food material becomes so scarce that the worms are forced to seek other places for their food. On such occasions, the worms migrate in great numbers and enter a corn field if it is in their path. The migrating worms climb the stalks and strip the plants of their leaves. The worms usually hide under clods of dirt and rubbish during the day and feed during the night.

There are several control measures for the armyworm. Infested areas may be mowed, covered with straw, and burned. Migrating worms may be destroyed by spraying, by scattering poison bait similar to that used for cutworms, or by trenching, as described for the chinch bug.

Grasshopper. There are several species of grasshopper. Almost everyone is familiar with the ordinary adult which does the damage to crops. The habits of the usual species are much alike. The grasshopper has no larval stage. The eggs are laid in holes burrowed in the ground by the female. They are enclosed in a sort of sack a little smaller than the average lead pencil in diameter and from ¾ to 1¾ inches in length. The eggs are somewhat smaller in diameter than the lead in a pencil, and usually about ⅜ inch in length, sometimes smaller. As many as 127 eggs have been found in a single egg mass laid by one of the large species of hoppers. Each female ordinarily produces two egg masses. The eggs remain in the ground over winter. The following spring, during May and June, the eggs are hatched. Young grasshoppers survive only in dry, warm surroundings. High humidity and heat with in-

termittent rain reduce the number of grasshoppers tremendously. In a season following a dry spring, grasshoppers may appear in damaging numbers. The young insects feed and grow and at intervals shed their hard skin. After the skin has been moulted for the fifth time, the insect is fully winged and the females are ready to lay eggs.

Ordinarily grasshoppers do not breed in corn fields, but they may invade them from neighboring ones where alfalfa, grain,

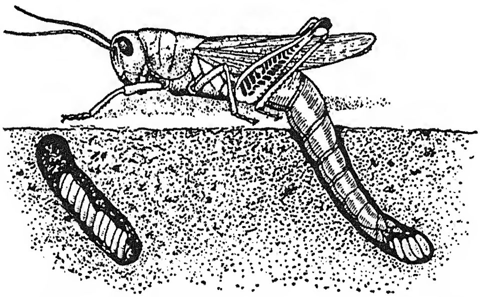

FIG. 33. Differential grasshopper laying eggs.

or grass is grown, or from unplowed edges of fields and roads. They eat the leaves, silks, and husks of the corn plant.

There are several control methods for grasshoppers. Be careful to use the dusts as directed by the manufacturer.

Recent experience with insecticides favors liquids. These are used on the foliage as a spray. Chlordane is the general trade name for a spray used on the growing vegetations adjacent to a corn field, effectively protecting the growing corn. Chlorinated camphene is a name used to designate spray materials. Directions are furnished at time of purchase. Emphasis is placed on the use of the poison while the grasshoppers are young. They are much more accessible before they enter the corn field. Control is more difficult but possible after they have begun to feed on the corn. Two or three applications along the edge of the field may be required. Spray is more

effective if applied when foliage is dry. Heavy rain removes some of the material.

Chlordane accumulates within the body tissues of animals. It appears to be insoluble in water. Small amounts may be eaten by animals without serious aftereffects. Experimental results indicate that rats are killed by eating sufficient amounts of it. Chlordane appears in milk produced by cows that have eaten hay made from plants treated with it. Such milk is not suitable for human food.

Grasshoppers prefer to feed on alfalfa rather than on corn. Some corn growers leave a strip of alfalfa next to the corn field for a grasshopper pasture, and the grasshoppers will continue to feed there and not move over into the corn field in great numbers.

Corn earworm. The earworm is the common greenish or brownish worm that eats into the ears of both dent and sweet corn. The adult is a brown moth.

As there may be three or more generations in one year, and each female produces 200 to 300 eggs, this insect can increase rapidly. It passes the winter in the pupal stage. The moth emerges early in the spring and deposits eggs which hatch by the time corn is planted. The first two generations live on the leaves, but the third generation attacks the ears.

The earworm is especially damaging to sweet corn and popcorn. This is particularly true of sweet corn that is being grown in large fields for canning factories as well as sweet corn in small gardens. In the southern part of the United States, the earworm does greater damage to dent varieties. The young worm begins to feed on the silks and kernels at the tip of the ear. The full-grown worm tunnels down the ear toward the butt end. The same worm feeds on the cotton boll, the tomato and tobacco bud, vetches, alfalfa, and many uncultivated plants.

Usually only one mature worm is found on any one ear of corn. This lends support to the theory that the worms eat each other. The corn breeder may control the damage done by the

earworm by the use of diethyl ether mixed with a light mineral paraffin oil. This mixture can be applied with an ordinary oilcan to the tips of the ears shortly after the silks are dried. It is applied by pushing the end of the oilcan a short distance in among the silks where some oil and diethyl ether is released. This process does a good job of protecting the ears. It probably is not practical in greater areas, since it requires from 35 to 50 man-hours in labor per acre to apply the mixture to every ear. There appears to be no reliable cheap method of controlling the earworm.

The practice of dusting corn fields, particularly fields of sweet corn, for control of earworms is now in the experimental stage. Dusting has been applied by a detasseling machine or by airplane. Good results have been reported from experimental fields.

Varieties of corn with long, tight-fitting husks are protected to a certain degree from the work of this worm. This worm works more in the southern part of the United States than it does in the northern part of the Corn Belt. With other insects it increases the demand for extra long and tight-fitting husks on corn for the southern United States. In the Corn Belt, corn planted late seems to be more susceptible to infestation of the earworm than early corn. Perhaps this is because the population of moths is greater at the time the silks appear.

Stalk borer. The chief importance of the stalk borer is the possibility of confusing it with the smaller European corn borer, described later in this chapter.

One stalk borer commonly found in the Corn Belt has broader, darker brown stripes than the pale stripes of the European borer. It does its work early in the season, whereas the European borer is most active after tasseling time. The common stalk borer does little damage, except occasionally along margins of fields. It lives through the winter in the egg stage on weeds around the fence rows.

Insects That Work on the Entire Plant

European corn borer. The European corn borer is one of the worst pests of the European corn belt. It was introduced in Massachusetts in 1917, probably in a shipment of broomcorn, and into southern Canada about the same time. Since then the pest has spread over the major corn-producing areas in the United States.

Corn borers may be seen by splitting a cornstalk from top to bottom with a knife. The borer is rather light in color with a darker head and a row of small dark-brown spots on each segment. Several dark-brown or pink lines extend lengthwise of the body. The full-grown borer is about 1 inch in length.

The adult is a moth which flies from place to place during late June and early July and deposits eggs on the underside of corn leaves. The eggs are laid in groups or masses from ten to twenty-five or more on a leaf. One female in captivity has been known to lay 1500 or more eggs in one season. The average per female is about 500. After the young worms have fed on the leaves a short period, they go down between the stalk and the leaf. From this protection they enter into the stalk or the tassel.

There have been no distinguishing names given to the different strains of corn borers which produce a different number of broods or life cycles in a season. Some insects kept in captivity produce only one brood in a calendar year; others produce two or three. The one-brood strain develops more slowly since the worm goes into a considerable resting stage before it pupates. The two- and three-brood strains seem to require no resting period and develop promptly from worm to pupa to moth. Careful observers believe that the larvae that are hatched during the second generation sometime in July or August are more likely to survive than the early brood that is hatched in June or July.

Evidence of damage may be observed in young corn plants rather early. A series of small holes or scars may be found in the leaves. These small holes are made by the young borers before they go down into the leaf whorls. A little later, a

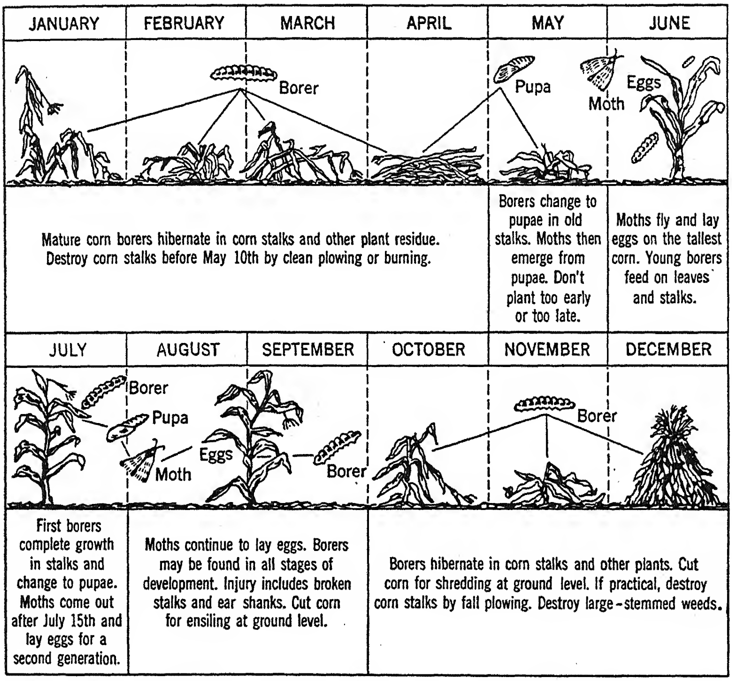

FIG. 34. The life history of a three-brood corn borer.

whitish substance is cast out of the stalk by the borer and may be seen at the opening where the borer entered. The midrib on the leaf may break, and close observation will show that the borer has been eating the pith out of the midrib. One of the most characteristic signs of borer damage is tassels with broken branches. The borers attack the corn at any point up and down the stalk.

The most damage to the corn plant comes from mature borers working in the cornstalk below the ear. What the borer eats causes damage to the plant. It leaves an opening into the plant through which various corn diseases may enter.

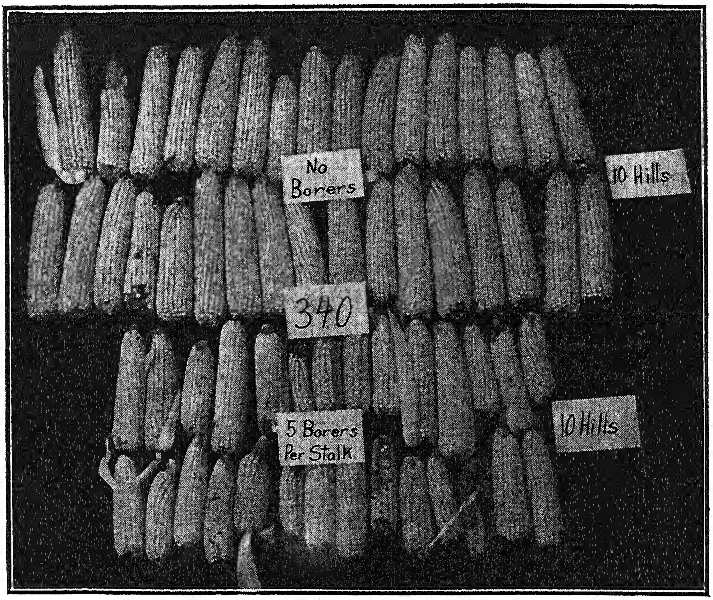

FIG. 35. The two rows of ears at the top of the picture represent the crop harvested from ten hills of corn in which none of the stalks were infested with corn borers. The two rows of ears at the bottom of the picture represent the crop from ten hills of corn in which each stalk had five borers.

These diseases may destroy a major portion of the inside of the cornstalk. There are veins (fibrovascular bundles) running up and down in the pith in cornstalks. These are important for carrying moisture and nutrients up to the ear. Any disturbance which prevents the movement of plant juices towards the ear becomes of economic importance. One corn borer per stalk may not be particularly important. Over five

corn borers per stalk may reduce an otherwise profitable field to almost a total loss.

During the first years of infestation, the corn borer causes little damage. For this reason it is easy for farmers to become skeptical about the seriousness of the borer during the first five years of infestation. So far there has not been developed any one remedy or practice that controls the corn borer. The moths fly freely from farm to farm, and controls are not satisfactory without cooperation of the entire neighborhood.

The corn borer lives through the winter in the worm stage, usually inside the cornstalk. If these cornstalks are left on top of the ground the borer stays alive, pupates, and then comes out of the stalk as a moth, in June and July. If these cornstalks and other trash are all plowed under a high percentage of killing is possible. The borer leaves the cornstalk when it is plowed under and comes to the top of the ground if it can. If there is a piece of cornstalk or trash he can attach himself to, the borer will stay there and survive to emerge later as a moth.

Corn fields that have been disked for oats are an ideal place for the corn borer to pupate. If the ground is clean and there is no trash on top, the corn borer comes to the top and perishes or is destroyed by birds. Varieties of insects that are parasites of the European corn borer have been imported and released in the Corn Belt. No reliable estimate has been made to determine their value.

The long-established practice of sowing oats without plowing the ground may have to be changed to plowing before the oats are sowed. Clean plowing for corn is essential. Previous to the arrival of the European corn borer, a few cornstalks were left on top of the ground, particularly if the soil was subject to wind erosion. Now these stalks merely mean more corn borers in the neighborhood. Cornstalks may be burned, but, with our decreasing amount of humus in the soil, burning the cornstalks is a practice not in accordance with best recommendations for soil fertility. If the corn crop is cut and put

into the silo, the corn borer is destroyed. If cornstalks are cut for fodder, the residue should be hauled to the field and plowed under before there is an opportunity for the worms to come out and pupate.

A mechanical corn picker which cuts the corn plant loose from the ground, husks the corn, and delivers the shelled corn and ear corn to a wagon or truck has been developed. This machine shreds the fodder, then spreads it on the ground. This process is reported to have killed 96 per cent of the corn borers in a field that was highly infested. This probably is one of the most promising control methods yet devised. Information on corn borers may be obtained from agricultural experiment station bulletins, and from the U. S. Department of Agriculture, Washington, D. C.

The European corn borer can cause as much damage to the corn crop as the boll weevil has caused to the cotton crop. Dusting or spraying corn fields is in the experimental stage. It is practical to dust a corn field by means of an airplane when the worms are small. During the summer of 1946 a few corn fields in southeastern Iowa were dusted with DDT, by means of a detasseling machine. The machine carried the dust over the top of the cornstalks. The cost was approximately seven dollars per acre for two applications. There was a perceptible reduction of corn borer damage in this field as compared to adjacent fields. A somewhat similar experiment was tried with spraying. There have not yet been enough experiments to establish the best methods for control.

The corn breeder has a problem in developing strains of corn that will grow a crop in spite of the corn borer. As yet there have been no strains developed immune to the corn borer, but some strains resist it more than others. Another requirement would be resistance to diseases which enter the stalk through the holes made by the corn borer. Certain strains of corn imported from Central America have been introduced into the Corn Belt. Some of these give promise of finally contributing an increased tolerance towards corn borers.

Several generations will be required before this characteristic can be incorporated in any of the commercial seed corn. Careful observations in sample corn fields indicate that European corn borers have been killed by parasites. In some fields 30 per cent or more are so destroyed.

Southern cornstalk borer. The southern cornstalk borer is one of the most destructive pests in the southern part of the United States. It does not seem to survive northern winters. Its favorite plant is corn, but it will live on other plants.

This borer should not be confused with the European corn borer. The southern corn borer's spots are darker in color in the summer, and there are no lines showing. It is about ¾ inch long with light yellow spots during the winter. During the feeding period it is conspicuously spotted with eight brown or black spots around the border in each segment, and two more behind these. The larva lives all winter in the cornstalk, similar to the European corn borer. Usually, however, the winter is spent in the lowest part of the cornstalk just above the roots. In the early spring it pupates inside the cornstalk. The adult moth comes out in the spring. It is most active at night. Each moth lays three to four hundred eggs on the underside of the leaves. The worms eat the leaves first, then enter the cornstalk. The southern cornstalk borer often girdles the stalk just at the surface of the ground. Plants are often dwarfed or noticeably enlarged at the base. The first generation becomes full grown in the middle of the summer

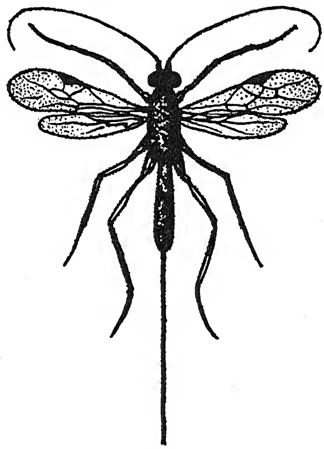

FIG. 36. One of the four types of corn-borer parasites liberated in Iowa in 1944. These were set free in fourteen counties.

and pupates in the cornstalks. The second generation stays inside and goes through the winter as a worm again. Control measures are clean plowing under of refuse from the corn crop and making sure that no hibernating larvae are in the cornstalks on top of the ground.

New insect controls. Agricultural experiment stations and their educational extension departments are rapidly increasing the knowledge about and uses of chemicals that may be used against insects that attack corn in the field. Commercial drug distributors, seed corn producers, and corn growers are financially interested in chemical control of insects. New drugs and improved methods of application can and should make many former practices obsolete.

Insects That Work on Stored Corn

Angoumois grain moth. The adult Angoumois grain moth is about ½ inch in width, light tan, with a few black, pepper-like specks on the wings. The edges of the wings of the moth have a very distinct fringe of fuzz. This hairlike material is very easily seen and may be a good means of identification. The larva lives over the winter in the kernels of corn. It goes into the pupa stage in the early spring and has a second generation during the summer. It comes out of the pupa stage as the adult moth. The eggs may be laid on grain in the field or in storage.

This is one of the most destructive insects of seed corn in storage. Hybrid seed houses may be heated (for the comfort of workers) in the winter in the north, and the worms live through the winter. If the seed storage buildings are not heated in zero weather and the corn has an opportunity to become as cold as the outside air, the larva inside the kernels will be killed. Another method of killing may be practiced in summer by increasing the temperature of the empty building to 125° F for several hours to kill any worms or eggs. Summer is more satisfactory because it is not difficult to raise the

temperature to 125° when the outside temperature is 80° or 90°. It is possible to fumigate against this insect if the buildings are tight enough to hold the gases. The gases used are carbon tetrachloride (CCl_4), calcium cyanide ($CaCN_2$), methyl bromide (CH_3Br), or chloropicrin (CCl_3NO_3). If these are used according to directions they will disinfect any building where grain is stored. Some of these gases are very dangerous and should be used only by professional experts. Perhaps the chief difficulty in controlling this insect is the fact that it works outside in warm weather and is, therefore, a serious pest to corn grown in the southern United States, or any other area in the world where the temperature is warm the year around.

Seed corn maggot. The adult form of the seed corn maggot is a small fly about 1/5 inch long. The fly looks like a house fly but is smaller. It appears in the fields early in May in the latitude of Illinois. The eggs are laid wherever there is decaying vegetable matter, or they may be laid on the seed corn or on the young plants. The eggs hatch at 50° F or warmer, and the worms are maggots that bore into the grain, often destroying the germ. When full grown the maggots are about 1/4 inch long. They change to the pupa stage in the soil. In ten days to two weeks they emerge as flies. A full cycle may be completed in three weeks.

This maggot is a native of Europe and was introduced into the United States about 1855. It has spread over the entire United States and southern Canada. In 1946 southwestern Iowa and northern Missouri suffered considerable loss due to reduction in stands of corn. Maggots do a great amount of damage by boring into the seed corn after it has been planted. No treatment of the seed is yet known that will control the maggot. Delayed planting in a seed bed that is warm, to insure prompt germination, helps to prevent injury to the crop. Injury is worse in cool wet seasons when the seed stays long in the ground before sprouting.

DISEASES OF CORN

There has been a great amount of work done on the diseases of corn. Some of the more important diseases are listed in the accompanying table. In no sense is this to be considered a complete list. Common names are furnished for many and the scientific name for most diseases. The diseases listed here are ear rots, stalk and root diseases, and smut and other corn diseases. Reference to the list will show that some are listed more than once. For example, Diplodia ear rot is also listed as a stalk disease.

There is no known seed treatment for completely controlling any of these diseases. Their importance varies from season to season. Pathologists know that weather conditions are sometimes favorable and sometimes unfavorable to disease. It is well known that some of these diseases thrive with high humidity during the growing season. Others do better in comparatively dry weather.

Genetically speaking, every one of these diseases is a problem for the corn breeder. Inbred lines and hybrids differ in resistance to practically all these diseases. Considerable progress has been made by corn geneticists against bacterial wilt or Stewart's disease. The Purdue Experiment Station has developed a sweet corn, P39 × P51, which shows what may be done and is perhaps the most successful genetic approach against any of these diseases. Progress has been made in the control of Helminthosporium by developing hybrids that are either partially immune or able to produce a satisfactory crop in the presence of the disease.

Rust control is also possible by genetic methods. Some hybrids already developed show marked resistance to this disease. Corn smut and head smut are definitely controlled by breeding hybrids that are immune or almost immune to smuts. Corn has been bred which is resistant to root rot. This was

TABLE 12

DISEASES

EAR ROTS	
Diplodia dry rot	*Diplodia zeae* (Schw.) Lev.
Diplodia white rot	*Diplodia macrospora* Earle
Gibberella ear rot	*Gibberella zeae* (Schw.) Petch
Gibberella kernel rot	*Gibberella fujikuroi* (Saw.) Wr.
Nigrospora dry rot	*Nigrospora oryzae* (Berk. & Br.) Petch
Rhizoctonia	*Rhizoctonia zeae* Voorhees
Other ear rots	*Penicillium* and *Aspergillus* Spp.
STALK DISEASES	
Diplodia stalk rot	*Diplodia zeae* (Schw.) Lev.
Bacterial stalk rot	*Phytomonas dissolvens* (Rosen)
Gibberella stalk rot	*Gibberella zeae* (Schw.) Petch
Charcoal rot	*Sclerotium bataticola* Taub.
LEAF DISEASES	
Bacterial wilt (Stewart's disease)	*Bacterium stewartii* E. F. Sm.
Brown spot	*Physoderma zeae-maydis* Shaw
Helminthosporium blight	*Helminthosporium turcicum* Pass.
	Helminthosporium carbonum Ulst.
Corn leaf spot (Southern U. S.)	*Cochiobolus heterostrophus* Drechs.
Rust	*Puccinia sorghi* Schw.
ROOT DISEASES	
Pythium root rot	*Pythium arrhenomanes* Drechs.
	Pythium graminicolum Subr.
Gibberella root rot	*Gibberella zeae* (Schw.) Petch.
Diplodia root rot	*Diplodia zeae* (Schw.) Lev.
OTHER CORN DISEASES	
Common smut	*Ustilago maydis* (DC) Cda
Head smut	*Sphacelotheca reiliana* (Kuehn) Clint
Black bundle disease	*Cephalosporium acremonium* Cda
Mosaic disease	*Virus*

done in the beginning of hybrid corn breeding, to insure a crop that would stand up.

TABLE 13

ESTIMATED FIELD LOSSES IN IOWA FROM DISEASES

Iowa Experiment Station

Disease	Percentage by Years							
	1939	1940	1941	1942	1943	1944	1945	1946
Smut (*Ustilago zeae*)	4.0	6.0	3.0	4.0	3.0	1.0	4.0	3.0
Gibberella root necrosis [*Gibberella zeae* (Schw.) Petch]	...	1.0	1.0	1.5	2.0	3.0	3.0	3.0
Diplodia root necrosis	...	....	....	2.0	2.0	....	1.0	1.0
Pythium root necrosis	4.0	5.0	5.0	6.0	10.0	10.0	10.0	10.0
Diplodia dry rot (ear)	1.0	4.0	5.0	6.0	5.0	2.0	2.0	2.0
Gibberella dry rot (ear)	...	0.5	....	0.5	2.0	3.0	0.5	0.5
Gibberella kernel	...	....	....	2.0	....	6.0	4.0	3.0
Nigrospora dry rot	...	0.5	1.0	1.0	0.5	1.0	0.5	0.2
Gibberella and diplodia stalk rots	0.5	3.0	1.0	1.0	1.0	1.0	1.0	5.0
Black bundle disease (*Cephalosporium*)	...	....	....	....	....	....	....	....
Rust (*Puccinia sorghi*)	...	....	....	....	....	0.5	1.0	0.1
Bacterial wilt	...	....	....	....	....	....	....	....
Total	9.5	20.0	16.0	24.0	25.5	28.5	27.0	27.8

Considerable research has been done on the relation between soil fertility and corn diseases. Corn diseases may increase in vigor because of low fertility within the soil or a limited supply of any element needed to grow a healthy corn plant. Perhaps some of the earlier work done with soil fertilizers gave promise of more disease control than was finally achieved. The absence of certain minerals in the soil, such as phosphorus or potassium, causes discoloration of the corn plant. These discolorations are similar to some of those associated with corn diseases and may be considered as diseases by the average farmer. The trained plant pathologist or the specialist in corn nutrition attempts and sometimes succeeds in distinguishing between lack of proper soil fertility and disease.

Seed corn diseases. A discussion of seed corn sorting appears in Chapter XIX. All ears that do not appear to be fully normal or are in any way affected by disease are dis-

carded. Serious disease damage to an ear of corn changes its appearance. It should, therefore, be recognized on the sorting table. Some hybrid seed corn producers do not sort one ear at a time. The lighter kernels and the heavier kernels can be separated by machinery after shelling.

OTHER PESTS

Raccoon. The raccoon attacks corn fields that are adjacent to or not far away from timber areas. Most damage is done when the corn is in the roasting ear stage. Considerable areas of corn may be seriously damaged or destroyed. Sweet corn in home gardens is likely to be a complete loss.

TABLE 14

OTHER PESTS

Raccoon	*Procyon lotor*
Franklin gray ground squirrel *	*Citellus franklini* (Sabine)
Thirteen-stripe ground squirrel	*Citellus tridecemlineatus tridecemlineatus* (Mitchell)
Missouri striped ground squirrel †	*Citellus tridecemlineatus bodis* (Bangs)
Fox squirrel	*Sciurus niger*
Gray timber squirrel	*Sciurus griseus*
True red squirrel	*Sciurus hudsonicus*
Pocket gopher	*Geomys bursarius* (Shaw)
Jack rabbit	*Lepus campestris*
Cottontail rabbit	*Sylvilagus* or *Lepus floridanus*
Norway rat	*Rattus norvegicus*
Crow	*Corvus americanus*
Blackbird	*Turdus merula*
Ring-necked pheasant	*Phasianus colchicus*

* The Franklin gray ground squirrel is the only understriped member of tridecemlineatus group.

† The color of the Missouri striped ground squirrel is more tan on the underline and may easily be considered of the same family as the thirteen-stripe ground squirrel.

Franklin gray ground squirrel. The gray ground squirrel is at home over the major portion of the Corn Belt. His full

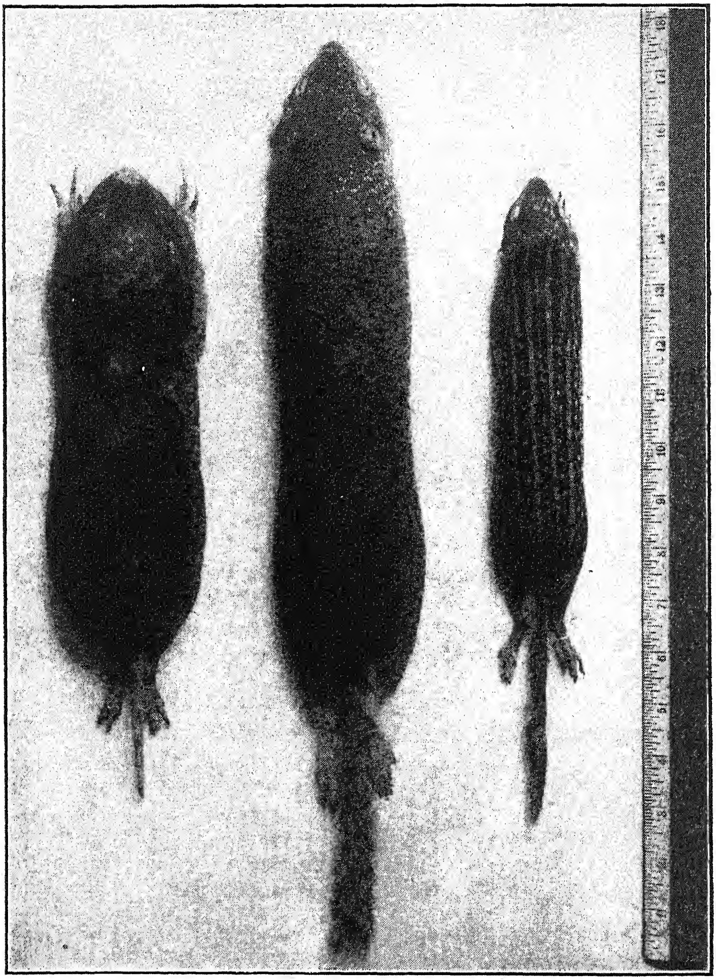

FIG. 37. Left to right: pocket gopher, Franklin ground squirrel, and thirteen-stripe ground squirrel. (Courtesy Iowa State Conservation Commission.)

length, including the tail, may be as much as 18 to 20 inches. His color may be called black-and-white pepper. The gray ground squirrel usually has his den in sod ground along fence rows, or at the edge of corn fields. He usually has two or more entrances to his den, which is 2½ to 5 feet underground. Damage to the corn field is done after the corn is planted and before the germinating kernel is absorbed. The squirrel digs the kernel out of the ground, even before the sprout appears. One pair of squirrels can ruin one edge of a corn field.

Thirteen-stripe ground squirrel. The thirteen-stripe ground squirrel is known in the northwest Corn Belt as the gopher and in part of Iowa and Missouri as the squinty. The maximum length for an adult squirrel, including the tail is 15 inches; many of them are not that large. The squirrel has his holes in the ground as does the gray squirrel mentioned above, and the destruction in the corn field is almost identical to that caused by the gray squirrel. He does not eat so much corn, but his numbers are likely to be greater and the distribution wider than that of the gray squirrel.

Fox squirrel, gray timber squirrel, and true red squirrel. These squirrels are not serious rodents against corn, except where corn is close to timber. These three live in the timber, but they will do damage to corn just planted if other food supply is not abundant. They can damage corn from the roasting ear stage to maturity.

Pocket gopher. The pocket gopher may be readily recognized by the mounds of soft dirt he leaves on top of the ground, some distance apart. The pocket gopher is about 1 foot long and has a short tail and very small eyes. He does not do a great deal of damage to the corn crop, but he does some, if other food happens to be short or if he develops an appetite for corn.

The six rodents mentioned above may all be controlled by one kind of bait. There is on the market an effective prepared material known as Gopher Death. About two pellets per individual is sufficient. Two applications a week apart at

the edge of the field is usually satisfactory. One other control method that should be mentioned in connection with these animals is the fox and the polecat. Encourage the residence of foxes and also the back-striped polecat, and these small rodents will not develop in great numbers.

Rabbits. Cottontail and jack rabbits do some damage to corn by eating the young plants when they first come up. The damage is more pronounced in arid areas than where the moisture is sufficient to make plenty of green material available. There is usually not much attempt made to control these rabbits.

Rats. Two kinds of rats do most of the damage to corn. The brown rat, sometimes called the Norway rat, is everywhere in the world. The black rat seems to survive better in the warmer climates.

Whenever corn is available for a source of food, rats do not go much farther. It has been estimated that one rat during one year of life can destroy or damage 4 or more bushels of corn.

The total number of rats per farm may be fifty or less; on the other hand, one farm may have more than 5000 rats.

Permanent storage space for corn can be built ratproof. Cement floors and foundations help. If the sides of the crib are lined with one-quarter-inch hardware cloth, rats cannot enter from the sides.

A wooden floor close to the ground allows rats to nest in the ground and eat from the corn above.

Poison is used extensively by corn owners who want to destroy rats. Drug stores can supply poisons along with directions for application. Agricultural colleges may provide detailed information through extension services.

Rat damage to stored corn includes the corn eaten, but more important is the dirt, manure, and odor which the rats leave with the corn. Such corn is reduced in grade if it has any market value. Beef cattle and more especially dairy cows may refuse to eat rat-damaged corn. Economically, rat con-

trol is exceedingly important to corn growers, corn shippers, corn dealers, and corn users.

Birds. The crow, blackbird, and ring-necked pheasant are all injurious to corn in some seasons and places. They pull the young corn out of the ground and devour what is left of the kernel. Pheasants and crows are probably the biggest culprits. Blackbirds sometimes do considerable damage when nesting areas are adjacent to the corn field. All these pests may be fed soaked corn, put along the edge of the field. If they have sufficient soaked corn they will not, as a rule, disturb the planted corn. Some farmers soak the corn in a poisonous solution in order to kill destructive rodents and birds.

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CHAPTER XIII

CORN FOR FODDER AND SILAGE

Corn fodder is the source of a large amount of feed for livestock. The entire plant including ears is referred to as corn fodder, and the stalks without ears are called corn stover. Silage is the corn plant cut into short pieces and placed in a silo. This chapter will deal with both corn fodder and stover, and also with the method of handling corn for silage.

CHOOSING VARIETIES FOR FODDER AND SILAGE

Farmers usually do not plant a special variety of corn for the silo. The silo is usually filled with corn that would otherwise have been satisfactory for harvesting for grain. In the dairy areas of northeast Iowa, Minnesota, Wisconsin, northern Illinois, Michigan, northern Indiana, Ohio, Pennsylvania, New York, and the New England states, a later corn may be used for silage than for grain. Even in these areas much of the silage is made from corn that is well adapted for grain. The states mentioned harvest up to 85 per cent of their entire corn acreage for silage. In areas where silage is produced and harvested, the demand is for hybrid corn. Hybrid corn usually stands up in spite of wind and bad weather and for that reason requires less labor for harvesting. See Table 3, page 17.

It is desirable to plant corn to be used for silage or fodder as early as that to be harvested for grain. The corn should mature early enough to be harvested before frost; in that way only is the maximum yield of dry matter obtained. In some instances where it was necessary to plant a field of corn late

in the season, it has been found desirable to plant the field to an earlier variety of corn to insure desired maturity before frost. This practice was made possible by the development of hybrid corn. Hybrid seed corn can be purchased which requires a very short growing season, or a long growing season. This information is nearly always available when the corn is purchased.

PLANTING FOR FODDER OR SILAGE

It really makes little difference whether corn for fodder or silage is drilled or checked. If the land is weedy, checking undoubtedly is the safest method as the weeds can be kept under control by cultivating in both directions. On clean ground or with contour farming, drilling is preferred. The plants will be more uniform in size with drilled corn. The corn binder and field harvester both operate more smoothly if the corn is evenly distributed in the row. On clean, fertile ground, greater yields of both fodder and silage may be obtained by drilling. The rows were formerly planted 3 feet 6 inches apart. A more recent practice in a great part of the corn-growing area is to have the rows 3 feet 4 inches apart. The kernels are dropped so that there will be one stalk every 8 to 12 inches in the row when drilled, and three or four stalks per hill when checked.

The thickness of planting should depend somewhat on the fertility of the soil and the amount of rainfall in the region, and perhaps to some extent on the length of the growing season. If the corn is not planted thick, the stalks grow rank and woody and there is a tendency for the crop to mature late. On the other hand if the corn is planted very thick the percentage of grain will be reduced. Corn Belt farmers who fill silos plant their fodder and silage corn much as they plant corn for grain. In general the same seed is used for both.

HARVESTING

The best results are obtained by cutting the corn when the kernels are well dented and hard and the lower leaves of the plant have turned brown. At this stage the corn plant has its greatest feeding value. In addition, it is in good condition to put into the silo. Although there is some difference of opinion about the best time to harvest corn for silage, it is generally conceded that immature corn does not make the best quality silage. When corn is cut too early, the silage has a dark color, contains too much acid, and lacks some of the feeding value. Some farmers prefer greener silage for feeding dairy cows than for feeding beef animals. Of course, it is desirable not to allow the corn to become fully ripe because the plants become more woody and leaves are lost. If, however, the corn becomes overripe before cutting, a good quality of silage can be made if water is added by running it into the blower with a hose while the silo is being filled. Sufficient water should be added to make it possible to pack the silage firmly.

Method of harvest. Corn fodder or silage may be cut by hand with a sled or platform cutter, with a power take-off corn binder, or with a row crop field harvester. Cutting by hand is slow, hard work, requiring an excessive amount of hand labor as compared to the corn binder or the row crop field harvester. There is very little corn cut by hand in the Corn Belt or in the area north and west of the Corn Belt proper. Where the fields are comparatively large and the ground is level, machinery is used extensively. The New England states, New York, Illinois, Iowa, Michigan, Wisconsin, Minnesota, North and South Dakota, Nebraska, Kansas, Oklahoma, Montana, Wyoming, and Colorado, cut more than half their fodder and silage by machinery. The states not named cut more than half of their corn for silage by hand, even up to as high as 96 per cent.

FIG. 38. Corn binder in the field with loader attachment delivering bundles to the wagon. (Courtesy International Harvester Co.)

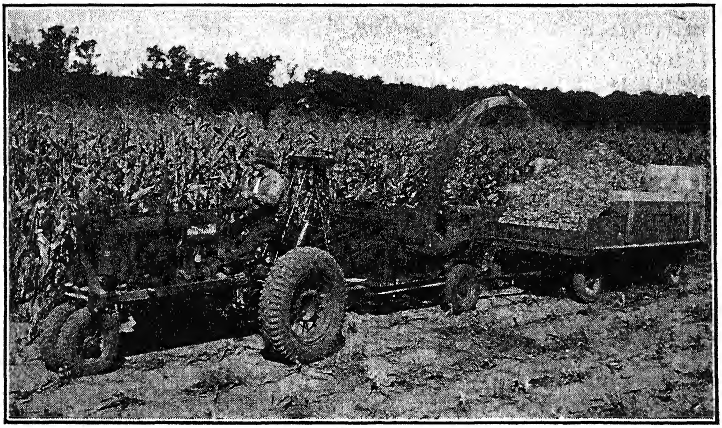

FIG. 39. Row crop harvester delivering chopped corn crop to trailer wagon for storage in silo as silage. (Courtesy J. Gehl Manufacturing Co.)

Hand cutting requires a man with a strong back and a corn knife. A sled or platform cutter is pulled by one horse or one mule and requires two men to operate it. It is a cheap machine and does not get out of order, but it is hard work. The corn binder is more popular because it is faster and easier. It derives its power from a so-called bull wheel by way of traction on the ground. This horse-drawn binder has been pretty much superseded by the power take-off corn binder, which is a machine similar to the original corn binder, except that it draws its power from the tractor which pulls it. The power take-off binder may harvest either one or two rows at a time. The row crop field harvester operates like a corn binder, except that it runs the corn through a portable chopper and delivers it to the wagon or truck ready for the silo. The popularity of the row crop harvester has increased tremendously since 1940. Both the power take-off binder and the row crop harvester need considerable mechanical attention. In the areas where they are used, farm operators have had considerable experience operating similar machines.

TREATMENT AND USE OF FODDER AND STOVER

Shocking corn fodder. Corn is more satisfactory fodder if it is shocked as soon as it is cut. Corn fodder is best if cut after it has turned somewhat brown and still has all the leaves. When corn is cut by hand it is usually shocked immediately while the man has it in his arms. It may be shocked with the aid of a wooden shocking horse. This is built something like a carpenter's saw horse. It has two legs rather than four, and one end stands 3 to 4 feet high. It is a very great aid in shocking corn by hand. This shocking horse is used extensively in areas where hand cutting of corn is common.

If corn is cut with the corn binder when there is still excess moisture in it, it may be allowed to lie on the ground a few days before it is shocked. In general, dry fodder may be

shocked in large shocks. Green corn full of moisture will keep better in smaller shocks. After the shocks are set up, the top of the bundle may be closely compressed with a small rope which has a ring at one end. Binder twine is then used to hold the top ends together, and the rope is released for use on the next shock. A shock so tied will stand very well through the winter. Shocking corn cut with the corn binder may be accomplished by using the shocking horse referred to above or by piling some bundles on the ground. One bundle is placed with the ears right on top of the stubs of a hill, and the next bundle at right angles to it, with the ears on top of the first bundle. The third bundle is put immediately on top, parallel to the first bundle that was laid down. This piling is continued until the crossed bundles are about waist high. The rest of the bundles may be set up around this pile of bundles laid crossways to each other. This is the fastest way of building shocks of fodder bundles.

Losses in corn fodder. There is a loss in feed value if fodder is stored in the field. No matter how well corn is shocked, the corn fodder will lose some feeding value. When the leaves become dry and the cornstalks become hard, they lose some of their taste appeal. Livestock do not eat old corn fodder nearly as readily as they eat fresh corn fodder. Therefore, corn fodder is much better feed in November and December than it is in March or April.

Utilization of fodder. Corn fodder may be utilized in the following ways:

1. Soiling crop—cut green and fed.
2. Dry corn fodder—cured in the shock.
3. Shredding—ears removed and stover torn in small pieces.
4. Stover—ears removed and stover fed.
5. Silage.
6. Miscellaneous uses, such as livestock bedding.

Corn is used as a soiling crop because of poor pastures in late summer. Many farmers feed green corn to their livestock.

This practice is almost universal in the United States. Corn is palatable at this time and is relished by all kinds of livestock. Early varieties or even sweet corn may be used to good advantage, for they are ready to feed in late July and early August in the central Corn Belt, a month or more sooner than would be desirable for other varieties of corn.

Most shredding machines husk the ears from the fodder and tear the fodder into small strips. This shredder kills a large percentage of corn borers that may be present in the fodder. The corn may be delivered to the truck and taken to the corn crib. It is important that the stover be dry at the time it is shredded. If it is not dry it will mold and spoil. Salt may be added when the stacks are built to help reduce heat and the development of molds. The practice of feeding fodder is more common in the eastern and northeastern states than in other parts of the corn-growing area.

When the ears are removed from the shocked corn the remaining fodder is referred to as stover. This feed is more suitable for beef cows and ewes during the winter than it is for fattening cattle or dairy cows. When available it is liberally used for the feeding of dairy heifers during the winter.

CORN SILAGE

Corn silage is the complete corn crop. Stalk and all is chopped into short lengths and delivered into the silo. The food value of silage is greater than that secured by any other method of storing a corn crop. Once the silo is filled, the silage may be fed practically without waste, as it is palatable and is readily eaten by farm animals. It is especially well suited for cattle and sheep but is not often recommended for horses. Silage furnishes a succulent feed in late winter when good feed is needed, and it is also a valuable food supplement in late summer and early fall when pastures are likely to be short. When corn is harvested as silage, the farmer is less

dependent on the weather and the crop may be stored in a smaller space and in a more convenient form for feed than is possible with dry fodder.

The use of silage crops dates back to the time of Caesar. The Romans stored green feeds for their horses in the ground. The Germans made use of silage for animal feed many centuries ago. However, silos have been used in the United States only since 1875.

Kinds of silos. Of the many kinds of silos in use today, there are three general types:

1. Trench or pit silos, built partly or wholly below ground.
2. Above-ground silos, built of brick, masonry, steel, or wood.
3. Temporary silos.

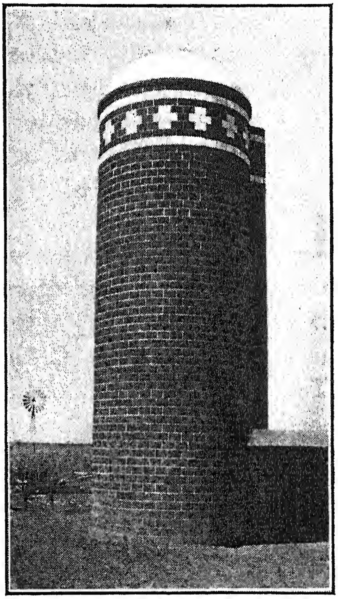

FIG. 40. Modern tile silo. (Courtesy United-Des Moines Clay Products Co.)

The trench silo is found mostly in the western edge of the Corn Belt and in the plains section. It is nothing more or less than a big ditch that is filled with silage. These ditches may be lined with cement, brick, or tile, or the silage may be stored against the earth. Loose dirt may be used as covering over the silage after the silo has been filled, or the top part of the silo may be filled with stover. If the top part spoils before it is used, the grain is saved. These trench silos need to be on high enough ground so that the moisture can drain out of one end. For convenience, trench silos should be wide enough so that a wagon or truck can be backed in from the lower end and the silage loaded from the open end of the trench. The pit silo may also be a cylindrical hole in

the ground. This is possible only where the water level of the area is not higher than the bottom of the silo.

The above-ground silo should be cylindrical in shape. It should be convenient for filling and emptying. Silos are not considered convenient if they are more than 40 feet high. The foundation should be durable and should extend below the frost line. A silo is more satisfactory if it is constructed and located so that it prevents freezing and resists high winds. It should be simple and exceedingly durable in construction. A permanent silo of neat appearance adds much to the farm.

Temporary silos may be a simple long ditch in the ground. Sometimes the ditches are lined with a cement wall. Silage put in such a silo can be covered with fodder and dirt to help prevent spoiling. Woven wire or snow fencing placed in circles on top of the ground also serve as silos. These are usually lined with tough paper at the time of filling. Very large temporary silos have been built of baled straw or bundles of fodder. Temporary silos do not keep the silage as well as more permanent structures.

The making of corn silage is a fermentation process which begins as soon as the silo is filled. The following changes are brought about:

1. Increase in temperature—85° to 90° F.
2. Evolution of carbonic acid gas—dangerous in pit silos.
3. Change in color—darker.
4. Aromatic odor—desirable.
5. Formation of acids—1 to 2 per cent of weight. a. Lactic acid—acid of sour milk. b. Acetic acid—acid of vinegar.
6. Formation of alcohols—1 to 4 per cent of weight.
7. Breaking down of proteins—no loss to silage.
8. Softening of the fibrous portion of the cornstalk due to the influence of the heat and acid.

These bacterial, physical, and chemical changes are practically completed at the end of two weeks, when the silage is made. Silage may be kept for years in a tight silo without

loss of palatability or value. It is important, however, that the silage be well packed and the silo very tight, because air permits the development of molds, which are sometimes poisonous and which quickly destroy the acids, thus allowing the silage to spoil. Bacteria which cause decay will not live and work in the presence of lactic and acetic acids when no air is present.

Yields of silage. Under average Iowa conditions, a 60-bushel corn crop will produce from 6 to 8 tons of silage per acre. With the more leafy and ranker growing hybrids now grown in the Corn Belt, a ton of silage normally contains about 6 bushels of corn. This indicates that a 60-bushel corn crop produces about 10 tons of silage. The shorter hybrids with less foliage give about the same corn yield but not so many tons of silage per acre. With some of these shorter growing varieties, it is possible to acquire 8 bushels of corn for a ton of silage. Exceedingly rank-growing hybrids planted 50 per cent thicker than the normal rate of planting may yield a ton of silage with only 4 to 5 bushels of corn.

Hauling to the silo. Most of the corn fodder for the silo is hauled on ordinary racks. The same is true if the corn is cut by hand. A low rack has some advantage in loading. The general custom is to have about six or seven wagons or trucks hauling, with an extra man at the cutter to help unload. The bundles are laid on the rack flat, with the butts one way. Usually the fodder is hauled as soon as the corn is cut, with two or more men in the field to hand up the bundles. One of these men may be eliminated, however, and considerable hard work dispensed with if the corn binder is equipped with a bundle elevator so that the wagon can be driven alongside the binder as it cuts. The objection to this plan is that if anything goes wrong with the binder there is no corn cut ahead and the entire crew remains idle until the binder is repaired.

When the silo is being filled with the field harvester, the wagons are loaded with the chopped material in the field and are brought in behind a truck or pulled with a tractor or

horses. A good field chopper can deliver chopped fodder to the wagon or truck that is following at the rate of 4 to 7 tons per hour. The variation depends on the yield in tons per acre and also very directly on the operator of the field chopper. When the field chopper is delivering a high tonnage per hour, the loads must move to the silo and unload promptly. Three wagons are satisfactory, unless the haul is too long. These wagons are moved with a tractor. One is in the field being filled; one is at the blower being unloaded, and one is in transit. These wagons are unloaded at a dump on a platform and moved into the blower by screw conveyors or drag chains. They may be unloaded by two men with silage forks. It takes the same amount of work inside the silo to keep the material level that it did when the cutter was stationary at the silo.

Filling the silo. Filling the silo with the ensilage cutter is considerably more of a problem than filling the silo with a row crop harvester and the blower. The man who feeds the green corn fodder into the ensilage cutter is responsible for the progress made. The more fodder he pushes through the machine the faster the silo fills. An important precaution is to see that the knife in the cutter is sharp at all times and that all bearings are greased regularly. It is also important to see that the capacity of the cutter is maintained by using a uniform amount of fodder. The amount of fodder to be fed into the machine will depend on the power driving the cutter and the size of the cutter. The cutter must be staked down firmly so that the wagons or trucks can get to it easily and so that the blower pipe can be placed as nearly vertical as possible. It is important that the manufacturer's recommendations for the revolutions per minute on the cutter be maintained. Most ensilage cutters have various speeds on the feeders. This speed controls the length at which the fodder is cut for the silage. The most popular length seems to be about ¾ inch. This is fine enough to pack readily and does not require as much power as is needed to cut silage shorter.

There is no need to have a group of men in the silo for tramping purposes. One can move the spout around and keep the top of the silage inside the silo comparatively level. This is important if the silage is to settle properly. If the silage does not settle uniformly, there will be air holes and soft places where mold develops. When a large quantity of silage is placed in a silo within a day, considerable settling results. In order to utilize the capacity of the silo it is well to refill the silo three or four days later. This is easily accomplished by having two silos on the same farm, side by side, so that the elevating pipe can be turned from one to the other without resetting the cutter. This is an advantage in working with a row crop harvester. The row crop harvester does the cutting in the field and delivers the chopped fodder to the truck or wagon that follows the harvester. The chopped fodder is then delivered to the silo and elevated by means of a blower.

Adding water. If corn is cut at the proper time, a good silage can be made without adding water. An inspection of the field for proper maturity of corn is necessary. The corn should be well dented and the kernels well glazed, and not too many of the leaves should be dry and dead at the bottom. The riper the ears are while the stalks are still green, the more satisfactory will be the silage and the higher the feeding value per acre, other things being equal. Good silage contains about 64 per cent moisture. If it does not feel wet to the hand, water should be added at the silo and mixed with the chopped material as it goes up the pipe. The water supply on most farms is not sufficient to allow too much water to be added to the silage, if the silage is coming from the field dry. An ordinary garden hose, fully open, does not supply too much water if the fodder is somewhat dry and brown. A little too much moisture makes better silage than can be made if the corn fodder is too dry.

If there is ample water where the silo is to be filled, a very good estimate of the amount required for dry fodder can be determined. This applies to fodder that is cut from the stalk

when it is overripe and also to fodder that comes in from the shocks. To determine the proper amount of water needed, some bundles of fodder or a given amount of whole stalks delivered from the field by the field harvester are weighed. This fodder is then immersed in water overnight. After the fodder is removed, it is allowed to dry for a sufficient time to allow all the outside free water to disappear. Then it is weighed again. The difference in the weight of the fodder before and after immersion gives a good indication of how much water is needed in pounds to supply the silage with sufficient moisture. If the fodder is fairly dry, it may take as many pounds of water as there are pounds of fodder; if medium dry, about 50 per cent as much water as pounds of fodder. Briefly, a ton of fodder that requires 50 per cent as much water as fodder would need to have water added at the rate of 1000 pounds for each 2000 pounds of fodder.

It is possible to calculate the water flow from a hose by measuring the amount delivered in five minutes and then calculating the amount delivered in an hour. Water weighs approximately 8 pounds to the gallon. It takes a sizable stream of water under pressure to get sufficient water on dry fodder to make good silage. If the water is not added much of the silage will be spoiled and useless as feed. An ordinary half-inch garden hose will deliver from 2000 to 3000 pounds of water per hour, depending on pressure and friction.

Preventing waste on top. Unless feeding is commenced as soon as the silo is filled, some of the silage at the top of the silo will spoil. This waste may be partly eliminated in several ways. One is to level off the surface and tramp it down firmly with finely cut chaff from the straw stack, thoroughly packed and wet down, or with water and sow oats. Satisfactory results have been obtained with tar paper spread over the surface with a thin layer of corn stover on top. Perhaps the most common practice is to remove the ears from the last two or three loads that go into the silo. If this is done and the silo

is tramped on top every day for two or three days the loss is not very great.

Preserving silage. Ground corn is added to grass silage. Grass and legume silage has increased tremendously in popularity since this silage may be put up with the field chopper. Some preservative is usually needed to make high-quality silage from grasses and legumes. The use of approximately 200 pounds of ground ear corn per ton of forage used thoroughly mixed with the ensilage at the blower or the cutter improves the feeding value of such silage. The ground ear corn is preferable to ground shelled corn. Ground corn is low in moisture, and when it is mixed with the grass or legume silage it helps reduce the total moisture percentage content of material going into the silo. Much of this grass or legume silage is delivered to the silo with approximately 70 per cent moisture. For example, 2000 pounds of grass or legume silage with 70 per cent moisture would deliver 1400 pounds of water to the silo. The addition of 200 pounds of ground corn with 15 per cent moisture would make the total moisture content 1430 pounds for the 2200 pounds of silage. If the total amount of moisture is divided by the total amount of silage, the percentage of moisture in the material going into the silo is 65 per cent. This figure is approximately correct for first-quality silage. Silage with more than 65 per cent moisture or even with 55 per cent moisture may be good.

Opening the silo. Silage may be fed as soon as the silo is filled, but for the first few days it is nothing but green corn fodder finely cut. When feeding is begun promptly, there is no waste on top of the silage. During the first few days fermentation takes place; then the chopped corn fodder gradually changes to silage.

Refilling the silo. After the contents of the silo have been fed out, the silo may be refilled with dry shocked fodder, if it is available. Dry fodder in the silo makes a very satisfactory feed, but it is not so high in value as silage from corn put in at the proper stage. When refilling the silo with dry corn fodder,

about 250 gallons or 1 ton of water should be added to each ton of dry fodder. The water may be run into the top of the blower with a hose, or it may be added as the chopped corn fodder goes up the pipe. It is well to remember that it takes more power to elevate the chopped fodder if the water has been added than it does to elevate the dry fodder in the pipe. It is not desirable to let the water run into the silo in one place, as it will form channels and leave parts of the silage dry. These dry parts will spoil.

Corn stover may be used as silage, but its feeding value is much lower than silage made from fodder. In the main part of the Corn Belt silage made from fodder or stover is of better quality if it is made before February.

Silage from frosted corn. If the corn to be used for silage is frosted while still quite immature, it is best to cut it soon after frost to avoid loss of leaves and to allow the corn to cure out to some extent before putting it into the silo. The reason for this is plain. The moisture content of corn that is frosted, say in the roasting ear stage, is too high to make good silage. If some of this moisture is allowed to evaporate, the percentage of water in the silage will not be over 65 per cent, which makes a satisfactory silage even with immature corn.

Corn silage versus other silage. As far as the content of protein and sugar is concerned, corn produces the most nearly ideal plant material for silage. Grasses and legumes at the proper stage for making good silage contain rather high protein in proportion to sugar content. Hence these require the addition of ground corn, as mentioned earlier in this chapter, in order to meet the sugar requirement.

Dairy sections in the southern Corn Belt, when infested with chinch bugs, have grown sunflowers for silage with fair results. Among the legumes, the most popular is alfalfa followed by clover, including sweet clover. Clover silage is improved by the addition of ground ear corn. Ordinary corn and soybeans may be grown together and harvested as silage. This practice used to be very common. Since the introduction of hybrid

corn, the growing of soybeans and corn together in one field has diminished in popularity. The vigorous growth of the hybrid corn has discouraged the habit of growing any other crop in the same field.

Characteristics of good silage. In buying, feeding, and judging silage, it is well to know the characteristics of good silage. Good silage should have the following characteristics:

1. Half-inch lengths (not long shreds).
2. Very leafy with few coarse stalks.
3. A large amount of grain in the stover.
4. Sweet and free from all molds.
5. Sharp odors of acid.
6. No objectionable odors.
7. Even distribution of moisture.
8. Maximum moisture not above 70 or below 50 per cent. (The best moisture percentage is between 60 and 65 per cent.)
9. Palatability.

Feeding silage. Silage is ordinarily fed to dairy cows at the rate of about 30 pounds per head daily with 10 pounds of clover or of other legume hay. Another custom is to feed the cows what silage they will eat and do the same with the hay. Dairy cows also get grain rations in addition to silage and hay. An excellent ration for carrying beef cows through the winter is 30 to 40 pounds of silage, 3 to 4 pounds of hay, and no extra grain, provided that the legume hay is of good quality. For fattening cattle a typical starting ration is full-feed silage and full-feed hay with ground corn added to the silage. The ground corn is increased in quantity from the beginning of the feeding period. Most beef cattle starting on feed get about 1 pound of protein concentrates. If the cattle take more ground corn they eat less silage and less hay. If the cattle are to be on feed for six months or more, the silage is probably entirely eliminated the last forty to sixty days. The hay feed will be limited to 4 to 5 pounds, depending on the size of the steer.

Silage is ordinarily fed to sheep at the rate of 2 pounds per head daily. Moldy silage is more likely to cause trouble with sheep than with cattle. Silage is not often fed to horses, because the molds are dangerous feed for horses. If it is fed to horses, about 15 pounds a day is sufficient. As a general rule, it should be remembered that it takes about 5 pounds of silage to equal in feeding value 2 pounds of good hay. For the best results with all kinds of livestock, silage should not completely take the place of hay, although in the central Corn Belt it usually pays with cattle if silage takes the place of three-quarters of the hay ration. The hay is an aid in encouraging cattle to chew the cud.

Measuring and valuing silage. To measure the silage in a circular silo, calculate the area of the circle either by squaring the diameter and multiplying by 0.7854, or by squaring the radius and multiplying by 3.1416. The area of the circle is then multiplied by the depth of the settled silage. This gives the number of cubic feet in the silo. If not much silage has been fed out, allow 40 pounds per cubic foot. At the bottom of the silo allow 45 pounds per cubic foot. Corn in the silo is worth as much as a similar amount of grain not in the silo. The fodder in the silo has a value equivalent to approximately 300 pounds of good hay per ton.

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CHAPTER XIV

CORN PERFORMANCE TRIALS

The best type of corn-yield test involves the growing of several strains of corn side by side on the same land to see which will perform best with the conditions as nearly alike as possible. Since the ordinary farmer is not in a position to do the careful experimental work in this kind of yield test, it is the custom for the experiment station and the corn grower's association within the given state to supervise the planting and the harvesting of all test corn.

Producers of hybrid corn, including individuals, corporations, and experiment stations, enter their corn in such corn performance tests. They are, to a degree, relieved of any responsibility of being prejudiced in favor of their own corn or against another entry. It is the purpose of the experiment station in cooperation with the corn grower's association to make an impartial and as nearly as possible complete comparison of the yield results of the various samples which are submitted for the test.

When the first corn-yield tests were established in Iowa in 1918 under the Iowa Corn and Small Grain Grower's Association, the yield was taken as the supreme standard of excellence. The highest yield indicated the most satisfactory corn.

More recently other requirements of varying importance have been added, according to the judgment of the committee who set up the regulations controlling the corn-yield test. These items, in addition to yield, are: stand, moisture content at time of harvesting, ear height, dropped ears, damaged corn, and lodging. Lodging includes broken stalks and leaning stalks. Dropped ears became more important with the in-

creased use of mechanical corn pickers. Damaged corn includes moldy corn or corn having any other characteristics that make it less desirable for market. The moisture content of the corn is obtained from a sample that is taken from each entry and placed in an airtight container. From these samples the average moisture content of the entries is obtained. Stand is important. Every sample within a given field is planted by hand, with the same number of kernels dropped per hill. A lower stand of one entry compared with the others usually indicates less vigor for germination and growth.

TABLE 15

RANDOM DISTRIBUTION OF SAMPLE SLANTING (15-DISK METHOD)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
I	*4*	*13*	*10*	*14*	*11*	*15*	*9*	*5*	*6*	*7*	*3*	*12*	*1*	*2*	*8*
II	*10*	*3*	*11*	*6*	*1*	*5*	*8*	*7*	*4*	*15*	*14*	*9*	*13*	*12*	*2*
III	*12*	*5*	*15*	*2*	*9*	*4*	*6*	*13*	*1*	*10*	*7*	*8*	*14*	*3*	*11*
IV	*11*	*7*	*2*	*10*	*14*	*6*	*3*	*12*	*15*	*9*	*5*	*13*	*4*	*8*	*1*

Planting scientific test fields. A test field is usually divided into ranges. In a range, two rows of any desired length (say ten hills) are allocated to each variety of corn. If there are fifteen entries of corn, the range will contain thirty rows.

In Table 15, the Roman numerals designate the range, and the Arabic numerals designate the number of varieties entered. The italic numbers indicate the identifying number given to each sample of corn. Thus each block with its italic number represents two rows of the corn bearing that number.

The different varieties of corn are usually planted in random order in a range; only rarely do rows of the same two varieties appear side by side in adjacent ranges.

If the same seed is submitted by the same people for different test fields in adjoining counties or other locations, the original entry number may be retained.

Early yield tests. The early yield tests were not all alike. Henry County, Iowa, had a yield test in operation in 1915; Floyd County, Iowa, in 1918; Benton County, Iowa, in 1919. Woodford County, Illinois, began one in January 1919 with 118 men entering corn. This is the famous Woodford County Krug Corn three-year comparison. There were no results published until the end of the 1921 crop season, at which time the corn submitted by George Krug was declared the winner.

Much of the preliminary work in establishing methods that could be based on experience was done in these tests. These early tests were all made with open-pollinated corn. They did attract attention to choosing corn for yield rather than selecting seed corn for a beautiful show sample. For ten to fifteen years after the beginning of the yield tests by the Iowa Corn and Small Grain Grower's Association, very considerable importance was attached to the highest yielding corn, as determined by the methods used in the yield tests. The yield tests pointed the way to a careful comparison of the seed corn available within the state. There had always been variations in weather, lack of uniform fertility in the field that was selected for growing corn for the yield test, to say nothing of early and late corn in the same field. The yield tests offered corn breeders a measuring stick for the results of their efforts in corn breeding. The measuring stick was not entirely accurate; however, it was exceedingly useful. Yield tests are still widely used by corn breeders to aid in the selection of more and better inbreds.

Strip yield tests. The strip yield test is planted on a much larger scale than the yield test just discussed. In planting a strip yield test, it is necessary to select a field where the fertility of the soil and drainage are as nearly uniform as possible. Also the crop history for the past three or more years should be quite uniform. The corn planter boxes are filled with one

kind of corn which is planted across the field and back again. Then another variety of corn is planted. With a four-row planter, eight rows are planted in each strip. A two-row planter plants four rows in a strip. From six to ten different kinds of corn may be planted in a test field. After all the samples have been planted once, the process is repeated as many times as is necessary to cover the area desired. At harvest time the records for position of the different varieties are referred to, and each kind of corn is harvested with the corn picker and weighed separately. Moisture samples are taken. From these data it is possible to get much the same information that is used in the experimental yield test. It is also possible in the strip test to take notes on ear height, lodging, dropped ears, and damaged corn.

The strip test has another advantage when the corn is picked with a mechanical picker. Not all hybrid corn is equally adapted for efficient harvesting by the corn picker. These variations in the corn may also be noted at the time of harvesting. With some hybrids practically all the ears are put in the wagon comparatively free of silks and shucks. With other hybrids the ears are knocked off by the picker. These ears on the ground will probably be wasted. Some hybrids shell much more corn in the field, while being picked with a machine, than others. The count of the shelled corn on the ground from one variety to another is very useful information. The mechanical damage to the ears or kernels of corn on the ear is not likely to be the same for any two varieties in a strip yield test. More husks may be left on the ears with one variety than with the adjacent variety.

Five- and 10-acre fields. In 1914 the state of Indiana started a 5-acre yield test which has been in continuous operation since that time. Illinois has had a 10-acre yield test since 1930. Iowa has had one since 1938.

These 5- and 10-acre yield tests are planted on the farm of the man who makes the entry. He may select any seed he wants. He may plant it in any way he chooses. The require-

ments are usually quite simple. For example, the Iowa requirements demand that the field shall be rectangular, or it may be irregular in shape if planted on the contour. The farmer who makes an entry cooperates with the corn grower's association of the state. This organization measures his field and supervises the harvesting to determine the yield. The rotation of crops previous to planting the corn and the drainage problems are all the responsibility of the man who is operating the farm. He may or may not use commercial fertilizer. Any cultivation methods which suit him are acceptable. From the results, the most recent 10-year records show that Indiana has an annual average of 170.58 bushels per acre for 5 acres. Illinois, on a 10-acre average, is next with 155.41 bushels, and Iowa is third with 151.37 bushels per acre on a 10-acre average. (Tables 16, 17, and 18.)

These records show that it is possible to grow 180 bushels or more of corn per acre on a 10-acre field. The same is true in some other states. This yield of 180 bushels is approximately three times the best average yield that the state of Iowa has ever made.

Many factors contribute to high yield. Proper selection of seed corn is imperative; correct date of planting is to be considered; high fertility of the soil is a must every time; enough and not too much cultivation is always necessary; and last, but not least, full cooperation of the weather helps on the final results. Ideal weather means heat and moisture at the critical and correct times, not too much heat or too much moisture at any time, no hail, and no tornadoes. Also, high yields cannot be obtained if there are many destructive insects present, or if disease attacks the corn seriously.

Significance of corn-yield tests. The strip yield test and the 5- and 10-acre field tests do have a significant meaning to the corn breeder and corn grower. Every careful corn breeder realizes that it is possible to have a high-yielding corn in a 10-acre field that would not do so well in a twenty-hill, replicated yield test. Furthermore some corn will stand up pretty

TABLE 16

ANNUAL INDIANA 5-ACRE YIELD WINNERS

Year	Winner	County	Yield per Acre
			bushels
1914	Norris McHenry	Bartholomew	112.1
1915	Walter Broyles	Delaware	105.4
1916	Fred Suhre	Bartholomew	106.0
1917	W. E. Browne	Fayette	101.2
1918	Everett McClure	Dearborn	108.0
1919	W. H. Baker	Greene	118.2
1920	W. H. Baker	Greene	128.8
1921	R. H. Hardin	Henry	129.0
1922	Hoyt Hardin	Henry	120.0
1923	Charles F. Hubbs	Perry	122.8
1924	Geo. J. Yarling	Shelby	118.3
1925	John Barnes, Jr.	Jefferson	143.9
1926	Wm. G. Nikam	Martin	129.1
1927	Harry Ayler	Jefferson	152.5
1928	O. L. Bryant	Allen	127.4
1929	C. C. VanHoy	Martin	130.8
1930	Karl Pankop	DeKalb	129.6
1931	Herman Pankop	DeKalb	156.2
1932	Herman Pankop	DeKalb	165.5
1933	A. C. Brown	Ripley	141.3
1934	Harold Pankop	DeKalb	182.6
1935	A. C. Brown	Ripley	143.4
1936	Karl Pankop	DeKalb	146.6
1937	Ralph Heilman	Bartholomew	179.1
1938	A. C. Brown	Ripley	151.0
1939	Clark Dellinger	Clark	180.1
1940	Paul Kerkhoff	Tippecanoe	156.8
1941	Herman Barrett	Gibson	190.1
1942	Herman Barrett	Gibson	181.6
1943	Robert Osborn	Daviess	170.2
1944	Alfred Bartelt	Dubois	163.8
1945	Earl Straughn	Vermillion	164.3
1946	R. O. Swaim	Parke	174.5
1947	John W. McCarthy	Gibson	173.4

TABLE 17

ANNUAL ILLINOIS 10-ACRE YIELD WINNERS

Year	Winner	County	Yield per Acre
			bushels
1930	C. E. Canterbury	Sangamon	100.40
1931	John W. Sprague	Pike	109.07
1932	M. McConnel	Rock Island	136.00
1933	J. W. Bailey	Rock Island	102.56
1934	George Shuman	Woodford	103.78
1935	Howard Clegg	LaSalle	121.54
1936	Clarence Baie	DeKalb	119.60
1937	Richmond Robison	Tazewell	131.10
1938	Richmond Robison	Tazewell	137.96
1939	Richmond Robison	Tazewell	155.41
1940	Everett Lofftus	Warren	125.56
1941	William Woods	McLean	174.32
1942	Paul Peabody	Christian	191.64
1943	C. M. Howard	Tazewell	136.21
1944	Forrest C. Woods	McLean	182.05
1945	Clement Gill	Stark	136.92
1946	E. L. Atkins	Warren	172.81
1947	H. T. Thompson	Knox	141.25

TABLE 18

ANNUAL IOWA 10-ACRE YIELD WINNERS

Year	Winner	County	Yield per Acre
			bushels
1938	J. H. Griener	Keokuk	135.18
1939	Raymond McClure	Poweshiek	163.23
1940	J. J. Boatman	Poweshiek	148.25
1941	C. O. Meyers & Son	Grundy	138.62
1942	Scott Halloway	Shelby	167.93
1943	D. W. Meyer	Sac	150.87
1944	W. J. Landgrof	Sac	161.92
1945	W. O. Tranbarger	Grundy	131.80
1946	Glenn Babbitt	Shelby	180.30
1947	Don Radda	Washington	135.61

well in a twenty-hill, replicated yield comparison because it has substantial wind break. The same corn may not make the same kind of high score against lodging if planted in an entire field. A man who grows corn to feed livestock or market has ceased to be greatly interested in the results of the scientific yield test. This same man is distinctly interested in a strip crop test on corn on his neighbor's farm. He is also very much interested in how John Doe grew over 150 bushels of corn per acre on a 10-acre field. Perhaps the corn growers who feed hogs and sell corn are more nearly right in giving their attention to larger fields, rather than being enthusiastic over the comparisons of corn in a scientific test. However, corn breeders still use the scientific yield test as a guide for their efforts in producing more desirable corn, and it continues to have a very distinct value. The correlation between the yield of corn in this kind of test and the 5- and 10-acre yield test is very satisfactory.

CHAPTER XV

SWEET CORN

SWEET CORN FOR CANNING PURPOSES

Sweet corn is grown extensively for canning purposes in Wisconsin, Minnesota, and Illinois. Additional states that are substantial producers are Maine, New York, Maryland, Pennsylvania, Ohio, Iowa, Nebraska, Indiana, and Washington. There has been a substantial increase in the amount of corn canned in recent years. The average is now well over twenty-seven million cases per year, on the basis of twenty-four No. 2 cans in a case. Most housewives know that a standard No. 2 can contains 1 pound 4 ounces of corn. Sweet corn is also popular as a frozen food, both on the ear and in the kernel. The only other canned vegetables that have a greater production are tomatoes and peas.

An average yield per acre of snap roasting ears from the field is approximately 3000 pounds. From this, the canning company packs between thirty-five and forty-five cases of canned corn.

Maturity. Sweet corn for canning purposes may be either overripe, in which case it is stiff and hard, or it may be too young. If it is too young, the yield is greatly reduced. The highest grade corn should have a flavor similar to that of corn just freshly taken from the field. It should contain no foreign material, such as silks, husks, or particles of cob, and the kernels should be uniform in color and at the appropriate stage of maturity. Corn should be at the "milk" stage for whole-kernel pack and at the "cream" stage for cream-style pack.

The less desirable grades of corn include an increasing amount of defects such as silks or husks, tough hulls, and poor flavor. It also may show somewhat different-colored kernels and may be either too young or too old to make perfect pack. All these details are important for producing canned corn of high quality.

Some hybrid crosses of sweet corn retain for several days a stage of development exceedingly satisfactory for processing. One particular cross retains a satisfactory canning quality for a period of six to eight days. Other hybrids retain superior canning quality for only two or three days. Corn should be picked about eighteen days after silking.

Grower's contract. Most sweet corn is grown by farmers who live near a canning factory. The factory offers the farmer a contract for growing sweet corn, based on delivery to the factory. The price per ton is established not by what the sweet corn may bring but by what is considered the earning capacity of the land in that particular community. It is usually on a per ton basis. The canning factory sells or gives the treated seed to the farmer and later designates the day of delivery of the crop to the canning factory. This date is so arranged that the factory may have a uniform flow of high-quality snapped sweet corn arriving daily. The canning factory arranges with the farmers to plant different varieties of corn on different days, in an effort to facilitate uniform flow of product to the factory during the canning season. Early-maturing sweet corn may begin the canning season. Later varieties arrive in order of maturity. Emphasis is placed on growing more satisfactory varieties from the standpoint of canning efficiency.

About 70 per cent of the sweet corn seed sold in the United States is hybrid seed. Sweet corn is planted much like any other corn. It is planted with the same planter used for ordinary corn, except that the canner usually provides special plates. It may be drilled or checked in the row, depending on decision of the farmer. It is cultivated much the same as any

other corn crop. One advantage is that the grower gets an early cash return for his crop.

By-products. By-products include the sweet corn fodder that is left in the field after harvesting. Before the introduction of mechanical snappers for harvesting, the sweet corn fodder was quite a livestock food item. The mechanical snappers now in use reduce the value of fodder left in the field. The knives on the newest sweet-corn harvesting machines remove the ears by cutting both the cornstalk and the shank of the ear. This cutting removes the ear from the stalk without much bruising of the soft kernels. The knives cut the fodder in two or more places. The fodder is not easily gathered off the ground for silage. The canning company usually piles up the husks and the cobs and the undesirable ears and kernels. This is called canning factory silage. It may be used by the canning company for feeding cattle, or it may be sold to local livestock feeders.

MARKET AND HOME GARDENS

Market gardens. The market gardener grows his sweet corn to sell direct to the grocer who handles fresh vegetables. The first corn that appears as roasting ears in any large market is usually corn shipped some distance from south to north. A little later, home-grown corn appears on the nearest markets. It should not be more than one day old by the time it arrives on the dining table. Emphasis is not placed necessarily by the grower on the palatability of the corn. It is quite likely to be placed on uniformity and size of ear. A medium-size or rather large ear is easier sold to the consumer than is a small ear. There is, however, a demand for high quality, and some market gardeners produce smaller ears of high quality. High quality, of course, means dextrine in great abundance, which makes corn look creamy and gives it a very tender hull. The market-garden corn delivered in any one day should be uni-

formly mature. The earlier this corn appears on the market, the more likely it is to bring the highest price of the season. Market gardeners plant early varieties early in the season to supply this demand. This is done even though the earliest varieties may be medium-size ears or even a little smaller. Market gardeners plant corn in different areas at different times so that they may have marketable roasting ears of satisfactory maturity for a good portion of the season of the year when roasting ears are popular among fresh-vegetable consumers. The rate of planting is very similar to that used for the canning factory. Methods of cultivation are the same. The damage from earworms is one of the hazards of growing sweet corn to be sold as roasting ears.

Home gardens. Sweet corn is almost universally planted in home gardens throughout the northern part of the United States. It even appears in some gardens in England occasionally. The home gardener plants an early variety as soon as he can work the ground. He also plants sweet corn about every week, beginning with the earliest planting, until sometime in July. Such corn should be planted in small rectangular areas rather than long rows. The rectangular areas have a distinct advantage because they insure almost complete pollination, which is not achieved with rows planted across the garden. Early corn is planted with early varieties and later corn with later varieties. A common practice is to select a hybrid which has both eye and taste appeal at the table and to plant this one hybrid each week during the planting season from April to July, planting just enough each week to supply the family demands. Hybrid sweet corn matures uniformly, and if these plantings are a week apart the old corn may be past the most appetizing age when the later planting is still too young. Blended hybrid sweet corn seed is recommended and sold by most seed houses. This seed contains early-, medium-, and late-maturing varieties. This practice helps produce prime roasting ears every day for the table. Such corn is not grown

for sale but for home consumption. If a gardener is willing to go to considerable effort, he can gratify his taste for excellent sweet corn.

SWEET CORN SEED

Between 70 and 80 per cent of the hybrid sweet corn seed is grown in the Snake River Valley, near Caldwell and Boise, Idaho. There is a little sweet corn seed grown in Connecticut, California, New York, Illinois, and Minnesota. However, the trend is towards growing more sweet corn seed in Idaho.

The total acreage in Idaho is 7000 to 8000 acres annually. About 66 per cent of the total sweet corn seed goes to market and home gardens. Around 34 per cent is used for canning factories. The seed is marketed in 100-pound bags. The inbred strains that make up the hybrids in hybrid sweet corn were nearly all developed at the Iowa, Illinois, Connecticut, New York, Indiana, and Maine experiment stations. One popular cross is P59 $\times$ P51, which makes up probably 40 to 50 per cent of the entire hybrid sweet corn crop. The remainder consists of a considerable number of both yellow and white hybrids. A part of the Idaho seed is certified by the Idaho Crop Improvement Association.

This corn is grown on irrigated land. The seed bed is irrigated and prepared previous to planting. Planting in the Idaho area begins late in April for the growing of sweet corn seed and continues until early May. This corn is planted much like that in other corn-producing areas of the United States, except that the rows are 30 to 36 inches apart. All the corn is drilled. The earlier varieties are planted 4 to 5 inches apart in the row; the medium varieties 7 to 9 inches apart; and the late ones 10 to 12 inches apart. If the seed bed is properly prepared the corn is not cultivated again until it is 6 to 8 inches high.

The pollen parent is usually an inbred, and the seed-bearing rows are either an inbred or a line cross. The line cross requires two closely related sister lines to produce a single cross. It is

exceedingly important that the ears for the canning factory be the same size from end to end, if possible, and of the same maturity when harvested. Removing the kernels from the cob in the canning factory is done by means of cutters. If the cob tapers too much the knives of the cutter do not work efficiently.

The corn is cultivated like any other corn and is detasseled like any other hybrid seed corn. When the ears are a little

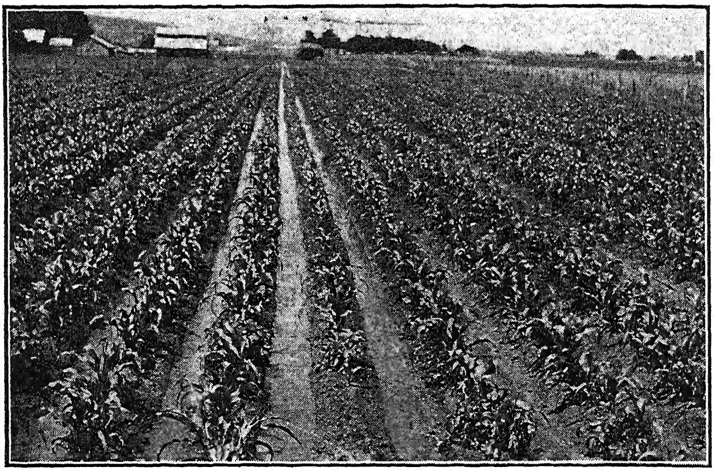

FIG. 41. Irrigation of sweet corn for seed production in Idaho. Idaho produces about 70 per cent of the supply of sweet corn seed in the United States. (Courtesy Crookham Co.)

more mature than is considered satisfactory for roasting ears, irrigation is stopped. The corn of the earlier types dries on the stalk, with minimum molding, to 14 to 16 per cent moisture, but the later maturing types and the late plantings have to be dried artificially. During 1943–1945 a large percentage of this corn was harvested with the combine or a corn picker. In 1946 a return towards hand harvesting was evident. It costs about $30 per acre to pick hybrid sweet corn seed by hand. This is equivalent to about $1.25 per hundredweight. The corn goes directly from the field and is sorted carefully over a conveyor

belt before it goes into the crib or dryer. All the shelled corn goes over a gravity machine, and all of it is hand-picked on a moving belt. This is done to insure the removal of every damaged kernel. The maximum temperature used for drying the corn is 100° F.

The sizing, sometimes called grading, is not so accurate as for dent seed corn. Sweet corn is not usually offered for market if it will go through a ¼-inch round hole screen. In thickness it is usually not more than $^{17}/_{64}$ inch.

The yields vary from 600 to 4000 pounds per acre, depending on the hybrid. For P39 × P51, the average yield per acre is about 1800 pounds.

If the trade demands the seed be treated with fungicide before it leaves the wholesaler, an extra charge is made.

Some of the corn is harvested by the combine and goes directly from the field to the shelled corn drier. After it is dried it is handled like the other seed.

Corn diseases and corn insects, except corn earworm, do a minimum of damage to sweet corn growing in Idaho. The dry cold winters do not permit vigorous growth of molds and similar diseases, and corn does not mold on the stalk so rapidly as it does in the more humid areas in the east and middle west.

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CHAPTER XVI

POPCORN

Popcorns have been widely grown and used since prehistoric times, but only in the United States have they become of real commercial importance. Throughout many parts of Latin America popcorn will be found either in out-of-the-way places where it has persisted since primitive times or in metropolitan circles where it has only recently been introduced. In parts of the Orient it is also commonly grown, though its distribution there is very spotty and not well understood.

Popcorns do not represent any one type of corn. They are merely any kind of corn that will pop. Though most varieties of popcorn have small, hard kernels, there are native popcorns in South America which have larger and softer kernels. Exactly why corn pops is not well understood. It is certainly connected with the percentage of moisture, but not in any simple way. Popcorn kernels can be broken into pieces without losing their ability to pop. At one time it was thought that the starch in popcorn might have a different structure from the starch in other kinds of corn, but careful work has failed to demonstrate any such difference. From the work of the Northern Research Laboratory at Peoria, Illinois, it is now known that all the starch grains of the endosperm are enclosed in a protein network. It is quite possible that the "poppability" of corn may have something to do with the nature or arrangement of this network.

Popcorn is raised by two entirely different groups of growers, the home gardener and the commercial grower. The home gardener grows a little in his garden to have some supply of his own. The large commercial grower raises popcorn to satisfy

the increasing demand for the finished product of popcorn in bags, already popped, ready to eat. These growers live in or near the major states which grow popcorn. There has been, among these growers, an increasing desire for a uniform method of presenting their product to the public. Accordingly an office of the National Association of Popcorn Manufacturers was opened in Chicago in 1946. This association has agreed on a uniform standard for measuring the expansion of popcorn by popping. Their device measures the popcorn when it is shelled and ready for the popper and again after it has been popped. The measurement is taken in a standard graduated cylinder. This measurement is a part of the required information for selling large quantities of popcorn to the manufacturer.

Factors affecting popping expansion. Earlier studies of popcorn led to the conclusion that a moisture percentage of about 13½ per cent is the most desirable for popping popcorn. This expansion causes the popcorn to increase fifteen to twenty times in size. When popcorn is needed in great volume for immediate sale, certain important details about popping must be considered in addition to the 13½ per cent moisture. The most satisfactory shortening for popping corn is cocoanut oil. In large-scale popping, the heat usually is provided by an electrically heated device. The temperature required varies from 300° to 450° F. Apparently every sample of popcorn has a few kernels that do not pop. In the trade slang these are "old maids."

In the Orient and in parts of South America corn is popped in a metal cylinder which blows out a plug when a certain pressure is built up by heating. This releases the pressure suddenly, and the corn is popped or "puffed." With such an apparatus it is possible to pop many kinds of corn which do not respond well to ordinary methods.

The average increase in volume of the open-pollinated popped varieties is nineteen to twenty times the original volume of shelled corn. Some hybrids increase substantially in

volume, even as much as thirty-two times the shelled corn volume.

The acreage and yield per acre of popping corn vary with the price and also with the weather. During the two extremely dry years of 1934 and 1936, the yield per acre was reduced to approximately 30 per cent of the normal average of around 1400 pounds. The profit in producing popcorn depends on the ability of the grower to furnish a product of good quality. It must be cured and stored with care if it is to market to advantage. Popcorn is more difficult to produce than ordinary dent corn. It must not be dirty, diseased, or worm-eaten, and it must pop. Growing popcorn is a specialized business and any farmer contemplating planting the crop must become acquainted with the practices of the trade.

Popcorn varieties. The kinds of popcorn grown in the United States vary widely, but little information about their history is in print. From colonial days until the middle of the nineteenth century the prevailing popcorns were small-kerneled flints, very similar to the northern field corns except in kernel size. White Rice and similar varieties held the field during the latter part of the nineteenth century. They have plump, sharply pointed kernels, on large cylindrical cobs. Several different varieties with small ears were introduced under the name of Tom Thumb. Some of these were of very high quality. A period of interest in popcorns for the home gardener in the 1890's resulted in the creation and introduction of many new varieties such as Yellow Pearl, Amber Pearl, etc. Since that time the outstanding events have been the introduction of Japanese Hull-less, the introduction of the variety South American, and the production of hybrid popcorn. Japanese Hull-less is produced on a short, wide-leaved plant which lodges badly. The ears are short and very broad, the number of rows very high, the kernels slightly pointed. It produces a popped kernel of high quality. The variety South American has yellow, rounded kernels, set on a long tapering ear. The plant is nearly as large as field corn, and the yield is high.

Hybrid popcorn. A. M. Brunson, first at the Kansas Experiment Station and then in Indiana, pioneered in the production of inbred lines of popcorn which gave hybrids of high yield and good quality. The commercial growers, who are growing substantial acreages of popcorn to supply the wholesale trade, have been quick to utilize the advantages of hybrid popcorn

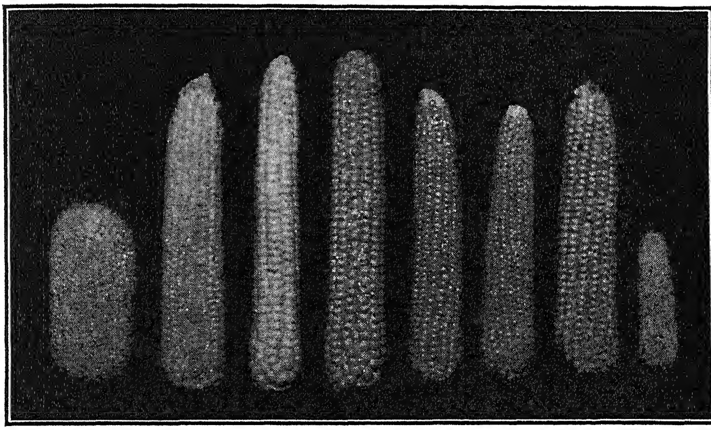

FIG. 42. Popcorn varieties. Left to right: Japanese Hull-less, White Rice, Spanish, South American, Yellow Pearl, Supergold, Superb, Tom Thumb. (Courtesy John C. Eldredge.)

seed. In certain areas two open-pollinated varieties are crossed by detasseling one, similar to the process for crossing two inbreds. The seed from this cross is used commercially. Another practice is top crossing with an inbred for a male parent and a satisfactory local variety for the female parent. This seed is used for commercial purposes. These methods of improving popcorn are almost identical to the methods of improving dent corn before there was a sufficient supply of hybrids to satisfy the demand for hybrid dent seed corn. The advent of hybrid popcorn is similar in its effects on the entire industry to the introduction of hybrid dent corn in the Corn Belt.

Marketing popped popcorn. The consumption of popcorn during the years of World War II increased tremendously. This was in part due to sugar rationing, which definitely reduced the amount of candy that was available for sale. In movie theatres, candy stores, and grocery stores, popcorn appeared in increasing amounts. In the army it was popular at PX stations around the world.

Popcorn used for packing. A limited amount of popcorn was used by the United States Ordnance plants for packing finished fragile instruments of war. Just how much popcorn was used for this purpose is not known. It was more satisfactory than other substances that were tried, and it was available in increased quantities rather suddenly when the price per pound advanced. Glass containers shipped to soldiers during the war were packed in popped popcorn and arrived at their destination in good condition almost without exception.

Storing popcorn after harvest. It is important that popcorn be dry when it comes from the field so that it will not mold in the crib. Careful growers want their popcorn cribs not more than 3 feet wide. These are often made mouse-tight with hardware cloth and are usually covered in an effort to keep English sparrows from doing damage. The storage of the corn as it comes from the field is important for protection against the weather and rodents. The percentage of moisture in this stored corn for wholesale use is not nearly so important as keeping the corn clean. Corn that is grown for local consumption will often get too dry for maximum popping expansion. The percentage of moisture in popcorn increases or decreases readily with the humidity change of air surrounding the popcorn. If popcorn is kept in the house for a week or more, it is quite likely to become too dry for popping. On the other hand, popcorn selected from the field in early fall is probably too wet for popping. Probably the easiest method of treating corn that is too dry is to put about one tablespoon of water in a quart fruit jar of popcorn, shake the jar well, and let it stand for a few days. If it pops, well and good; if it doesn't pop, take

the lid off and let the corn dry for about six to twelve hours.

The commercial preparation of large volumes of corn for popping requires moisture tests, and the proper amount of water may be added to such amounts of corn as may be needed for the next day's use, or the corn can be stored in humidity chambers which carry the proper amount of humidity in the air to insure proper maximum expansion.

Color of popcorn. Popcorns might theoretically be of the same colors as any other kind of corn, but the trade has come to prefer either yellow or white. Varieties with a red pericarp or with dark aleurone are sometimes grown by the home gardener. One of the difficulties in producing and breeding popcorn is the fact that there are two different genes for colored aleurone, both of which must be present if color is to be produced. Some light-colored popcorns have one and some the other. Crosses between these white or yellow varieties will bring the two color factors together and produce an undesired blue or black color in the aleurone layer of the hybrid.

Cultural methods. In general the methods employed for growing ordinary dent corn may be used for growing popcorn. The greatest difficulty will probably be weed control. Popcorn grows more slowly then does dent corn and the weeds get ahead of the crop. Hence it is important to have a seed bed where weeds may readily be controlled, or a field where the number of weed seeds is much below the average.

Seed. In selecting seed for growing popcorn, it is necessary to consider the length of the season where the corn is to be grown and then select a variety, or a hybrid of the proper maturity. It is essential that there shall be a minimum of soft starch in the kernels. Soft starch content in the kernel, due to immaturity or heredity, reduces the market value. Popcorn crosses rather readily with other types of corn. This foreign pollen does not seem to affect the popping expansion or eating quality of the immediate crop. This out-cross corn, however, is not satisfactory for seed.

In planting for the production of hybrid popcorn seed, it is essential that isolation or distance from other corn be carefully managed. Perhaps a few grains of foreign pollen from another good variety of popcorn would not be nearly so bad as pollen from dent or sweet corn.

Soil. Soil used for popcorn should be the same soil that is satisfactory for dent corn. The fertilization and rotation methods discussed for dent corn apply quite generally to the production of popcorn.

Planting. The regular planting rate for popcorn is usually higher than for dent corn. Five kernels per hill in checked corn is satisfactory. Most corn planters are supplied with plates that are used for cane or sorghum, and these may be used for planting popcorn. An acre requires from 3 to 7 pounds of seed, depending on the rate of planting and the size of seed. Cultivation is primarily for weed control, but it must be very carefully done, particularly in the early part of the season, because popcorn grows slowly at first.

Diseases and insects. The enemies of popcorn are approximately the same as those of dent corn, and methods of control are similar. With the advent of hybrid seed, some diseases may be reduced. One of the worst insects attacking popcorn is the earworm. It not only destroys the kernels but increases the opportunity for mold injury. Chinch bugs should have special mention, since they like to live in sunshine and are particularly attracted to popcorn fields where the sunshine reaches the ground. Therefore, popcorn may suffer severely in seasons when chinch bugs are plentiful.

Harvesting. The quality of the finished product is more desirable if the popcorn is left in the field until it becomes thoroughly ripe and the moisture content has been so reduced that the corn will keep when put in the crib. Increased amounts of popcorn are being picked with mechanical pickers. The snapping rollers are usually set closer together. Some picker manufacturers have special attachments designed particularly for harvesting popcorn. Some of the eastern states cut pop-

corn, shock it, and allow the ears to cure in the shock. In some western states where irrigation is popular, the water may be turned off at the proper time in development. In the areas most desirable for growing popcorn by irrigation, the humidity of the air is less than in the Corn Belt proper. The corn may be allowed to dry on the stalk and harvested with the combine.

Wholesale marketing. Popcorn is usually sold 70 pounds of ear corn to the bushel, or a price quotation may be on 100 pounds of shelled corn. The United States production for 1945 was 434,800,000 pounds, and for 1946, 266,752,000 pounds. This reduction indicates a substantial decrease in demand.

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CHAPTER XVII

WAXY CORN

Waxy corn is an example of the way in which yesterday's scientific curiosity may produce tomorrow's practical possibility. Corn with a peculiar waxy kernel has been widely grown in the Orient for at least several centuries. It was brought to the attention of the western world by G. N. Collins of the U. S. Department of Agriculture, and the waxy quality of the endosperm was shown to be dependent on a single gene. At first its only use was in technical genetical studies, but by the approach of World War II enough was known about the effect of the gene on the endosperm and its manner of inheritance to develop this type of corn quickly into a wartime substitute for tapioca.

The U. S. Department of Agriculture, in cooperation with such experiment stations as that at Ames, Iowa, had determined that the effect of the waxy gene was on the fundamental nature of the starch itself, producing a highly branched molecule similar to glycogen instead of one whose carbon chains are relatively unbranched as in ordinary starch. The resulting carbohydrate is gummier and has many of the characteristics of tapioca. Tapioca is produced from the root of the *Manihot esculenta.* It comes from the tropics where it is widely grown under a variety of names, "cassava," "yuca," "manioc," etc., and forms an important native food. Originally imported into the United States as food, it eventually became widely used in various industrial processes so that, when commercial supplies from the Orient were cut off during the war, an efficient substitute for it was a matter of general concern. By making properly controlled crosses and growing

them in the greenhouse, a commercial hybrid dent corn was turned into a waxy corn in a miraculously short time. By the second year of the war, hybrid waxy corn was being produced in commercial quantities and was promising enough to be continued even after the raw product for the manufacturing of tapioca was again available. Since it is not identical with tapioca, it is superior in some ways and inferior in others. The comparative costs of producing and importing it will depend upon world conditions. Only time can tell to what extent it may be grown in the future.

In 1946 the waxy corn crop covered approximately 20,000 acres, 17,000 in Iowa and 3000 in Illinois. The 1947 crop was approximately the same. This corn is grown like any other corn so far as the producer is concerned except that it must have a certain amount of isolation from other corn. Attention is paid to possible pollen from field corn, particularly to the south and west sides of a field growing waxy corn. Recent reports indicate that an infection of 5 per cent foreign pollen is not sufficient to destroy the desirability of waxy starch for commercial purposes. When waxy corn was first grown, the hybrid was not too popular. Considerable financial inducement had to be offered to get the farmer to grow it. The present inbreds used to produce waxy corn are considerably improved over the earlier ones, and the standability of the corn has been improved.

The grower is paid according to the market grade of his corn on the date of delivery, plus a substantial percentage of the Chicago price for a similar grade of corn. The corn is shipped for processing either to Roby, Indiana, or Indianapolis, Indiana. Reports on the 1946 crop emphasize again that the waxy starch produced from waxy corn is more satisfactory for some commercial purposes than tapioca starch.

Waxy sorghums have also been developed. They are not so easily milled as corn. It is more difficult to remove the hull, and it is almost impossible to remove the germ from sorghum. Waxy corn has an advantage in milling in that the oil is ex-

tracted during the milling (see page 78) and is usually worth about half the original cost of the corn. In addition the by-products are sold as animal feed. These by-products give corn an advantage, if the cost of Kafir corn sorghum maintains its market relationship of something like 85 per cent of the price of corn. It is interesting to note that the commercial processors who formerly processed tapioca are now processing waxy corn and so far have increased their use of it each succeeding year. The demand is expanding for the use of pastes, starches, etc., made from waxy corn.

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CHAPTER XVIII

CORN AS AFFECTED BY TEMPERATURE AND RAINFALL

Corn requires abundant moisture and a moderately high temperature for best growth. Laboratory experiments indicate that, when plenty of moisture is available, a temperature of about 90° is most favorable both for germination and growth. Growth stops altogether at temperatures below 40° or above 118°.

Temperature for germination. In most corn-growing sections, the temperature during the week following planting is around 60° to 65°, and under such a temperature corn usually appears above the ground in eight or ten days. When the ground is cold and the temperature averages 50° to 55°, the corn usually takes eighteen or twenty days to come up. When the temperature is less than 55° the slowly sprouting corn kernels are very susceptible to root rot infections, whereas when the temperature is above 60° the kernels are more resistant. If the soil is warm and moist and the corn is planted shallow, a temperature of 70° will bring it above ground in five or six days. In the central part of the Corn Belt, yield and temperature records indicate that a mean temperature of 55° or less during May tends to reduce the yield by about 15 per cent. A temperature of 56° to 58° will not ordinarily cut the yield by more than 3 or 4 per cent, unless accompanied by heavy rains and prolonged cloudy weather. The higher the average temperature in May, the better the yield of corn in the Corn Belt states east and north of the Missouri River. The opposite relationship holds in Nebraska, Kansas, and Mis-

souri, where above-average temperatures are usually accompanied by dry weather.

Temperature and rainfall during June. From the time the corn comes up until it reaches a height of 3 feet, it is necessary, under practical farm conditions, to give three or four cultivations in order to kill the weeds. This can be accomplished most effectively when June is rather hot and dry. A mean temperature of 70° to 72° in June, with 2 to 4 inches of rain, seems to be ideal. A mean temperature of more than 75° for the month of June is so often accompanned by exceedingly dry weather, not only in June but also in July, that it is a matter of history that years of exceedingly hot Junes are usually years of below-average corn crops. Warmer-than-average June weather is favorable to corn in Ohio and Minnesota, but it usually reduces the yield in Missouri, Kansas, Nebraska, and South Dakota. The greater the rainfall in June, the better the yield of corn in Kansas and northern Iowa.

July weather and corn yield. In Ohio, Indiana, Illinois, Missouri, Kansas, Nebraska, and southern Iowa, the rainfall and temperature during the ten days before and the twenty days following tasseling time have more to do with corn yield than the weather at any other period. Ideally, there should be 4 or 5 inches of rainfall during this thirty-day period, and the mean temperature should average from 72° to 74°. Corn appreciates mean temperatures as high as 85°, but, as a practical proposition, mean temperatures above 75° nearly always lower the yield for the reason that such temperatures cause the corn plants to require water more rapidly than they can take it up from the ground. This might not be true under irrigation, but in the Corn Belt mean temperatures above 75° are usually accompanied by drought. It is also true that a drought which would cause very little damage at 70° may be a serious matter at 80°, for it has been found at the Nebraska station that a full-grown corn plant will transpire daily about 4 pounds of water at a mean temperature of 70°, whereas at 80° it will transpire about 7 pounds.

During this thirty-day period, on land capable of producing 50 bushels per acre under favorable conditions, each degree that the mean temperature averages above 74° cuts the corn yield.

In the production of a good corn crop, ample rainfall is more important during July than in any other month. This is true in all parts of the Corn Belt. The higher the July temperature, the smaller the yield of corn in all Corn Belt states except Minnesota, where warmer-than-usual July weather ordinarily is needed to produce an above-average crop.

A general 1-inch rain during late July often increases the prospective crop of the Corn Belt states by 2 or 3 bushels per acre, or by a total of more than 100,000,000 bushels. Some people have, therefore, spoken of such a rain as worth millions of dollars to the farmers. As a matter of fact, December future corn prices as set by the Chicago Board of Trade during July and early August reflect these rains in such a way as to leave the total prospective value of the new crop changed but little. The rain which increases the prospective corn crop of the Corn Belt by 100,000,000 bushels, or by 7 per cent, will also lower December corn future prices by 6 to 12 per cent. The July and early August rains which add 100,000,000 bushels to the coming crop of the Corn Belt usually result in the new corn being priced 4 or 5 cents a bushel cheaper, or enough to make the total value actually somewhat less than if the rain had not come. It is the corn product manufacturers, exporters, and stockmen, who buy more corn than they raise, who benefit by the July and August rains which increase the corn crop. And, of course, it is always true that those corn sections which receive heavy July rains when the Corn Belt generally is hot and dry benefit enormously at the expense of their less fortunate neighbors.

December future corn prices and July weather. Generally speaking, the Chicago December future corn price, as quoted day by day during July and August in the daily papers, is the best measure for the average farmer of how the new crop of the

entire Corn Belt is being treated by the weather. If on July 30 the December future price is 6 cents a bushel higher than on July 20, it is an indication that there has been practically no rain anywhere in the Corn Belt during the past ten days. If the price during this period has dropped by 2 cents a bushel, it is almost certain that there have been abundant, well-distributed rains over the greater part of the Corn Belt. Sometimes December corn futures during July and August are affected to some extent by business conditions and by wheat prices, but as a rule they move up and down in sympathy with Corn Belt weather and very little else.

Northern Iowa and southern Minnesota differ from the central part of the Corn Belt in that they are more likely to be damaged by cold and wet during May and June than by heat and drought during July. It is only in years of exceptional drought, like 1894, 1901, 1934, and 1936, that the northern part of the Corn Belt is likely to suffer much from hot July weather. Even in such years the corn of the northern Corn Belt is usually not so very far below normal, whereas there is a great shortage of corn in the central and southern parts. As a rule the net result of dry, hot July weather, so far as northern corn farmers are concerned, is prosperity at the expense of the corn farmers farther south. On the other hand, cold, wet summers like those of 1915 and 1917 hurt the corn yields in the north and boost those south of central Iowa.

From a commercial standpoint, drought and heat during July and early August have much more effect on the corn market than cold and wet at any time of the year. In the droughts of 1934, 1936, and 1947, the greatest changes in corn prices occurred from July 1 to August 20. The great reductions of nearly a billion bushels in each of these years brought sharp increases in prices. (See Table 29.)

August weather. Over most of the Corn Belt, heat and drought during the first half of August are almost as likely to hurt the corn crop as heat and drought in July. Missouri, Nebraska, and Kansas corn is especially susceptible to heat

damage during the first half of August. North of central Iowa, however, the corn yield is more likely to be damaged by cold weather in August than by hot weather. August weather averaging below 69° seems to damage the corn crop in northern Iowa and southern Minnesota, especially in years when the May, June, and July weather has also been a little cooler than normal. The ideal August weather is a temperature of 72° to 73° and a rainfall of 4 or 5 inches.

After August 20, the weather usually has little significance. The corn plant at this time is storing food more rapidly than earlier in the season. Nevertheless, thirty days after tasseling, moderately dry weather seems to do no damage. Rainfall is important while the young corn kernels are just forming but is not so necessary when the corn plant is most actively at work storing food in these kernels during late August.

Frost. Frost has far less effect on the corn crop than most people think. In a season which has been unusually cool throughout, as in 1915 or 1917, a September frost may cause much soft corn north of southern Iowa. Occasionally, as in 1920 and 1927, unusually warm September weather enables the corn crop to avoid the frost damage which seemed almost inevitable. Only rarely does frost cause any widespread damage to corn. As a rule the farmer's corn crop is sufficiently matured to withstand frost damage two or three weeks before killing frost actually comes. Frost damage is rarely reflected in the price of corn on the terminal markets in the same way as heat and drought damage.

Heat and rapidity of growth. Although mean temperatures above 74° during the twenty days following tasseling time seem to harm the corn crop, it is also true that, previous to tasseling, the rapidity with which the corn grows depends largely on the temperature. During June and early July, corn grows twice as fast on days when the mean temperature is 78° as it does when the mean temperature is only 62°. A 75° mean temperature results in about 25 per cent faster growth than 70°. A number of years ago, the Pennsylvania

Experiment Station found that during the three weeks preceding tasseling time there was a tendency for corn to grow in twenty-four hours at the following rates at varying mean temperatures:

65°	3.2 inches
70°	4.1 inches
72°	4.5 inches
75°	5.1 inches
78°	5.4 inches

The average temperature during the fifty or sixty days following planting time is the chief influence determining just when a given variety of corn will tassel. With ordinary Corn Belt dents, the temperatures during the sixty days following planting result in varying lengths of time until tasseling:

68°	71 days from planting to tasseling
70°	67 days from planting to tasseling
73°	59 days from planting to tasseling

With a so-called ninety-day strain, the corresponding table, based on temperatures during the forty-five days following planting time, is:

67°	57 days from planting to tasseling
69°	50 days from planting to tasseling
71°	45 days from planting to tasseling

All three of the tables given here apply most accurately to average Corn Belt soil. On soil of unusual fertility the rate of growth will be somewhat more rapid.

The number of days from tasseling to ripening does not vary with the heat in the same clear-cut fashion as the number of days from planting to tasseling. Most varieties of corn take from fifty to fifty-five days from tasseling to maturity with ordinary temperatures. The dry, hot August, September, and October, 1947, experienced in the western Corn Belt shortened the required maturing time for the season.

Extremely high temperatures (above 95° during the heat of the day) may kill the pollen within an hour or two after it is shed and thus cause poor pollination if the high temperatures continue day after day at the time the pollen is flying. The storing of food in the corn kernel during late July and August is an altogether different process from the rapid growing of the corn plant during late June and early July. Hot weather does not have so much to do with hastening ripening as it does with causing rapid growth before tasseling.

Cold nights. It is a common belief that corn will not grow satisfactorily in regions where the nights are cool though the days are warm. Usually there is another explanation why corn is not grown in such sections. In South Africa, where corn growing expanded at a phenomenal rate after 1900, the minimum temperature at night during the tasseling season averages only about 60°, and in some sections it is as low as 55°. Cool nights reduce the rapidity of growth previous to tasseling, but if the season is long there is no definite proof that cool nights (55° to 60° at the low point of the night) reduce the yield. In many parts of Latin America corn is grown at high altitudes when every night is very cool (about 50°). However, it may take a year or even longer to mature a crop.

Summary. The ideal corn season in the central part of the Corn Belt is about as follows:

May—65° mean temperature (warmer than average), 3.5 inches of rain.

June—71° mean temperature, 3.5 inches of rain.

July—73° mean temperature (cooler than average), 4.5 inches of rain.

August—73° mean temperature, 4.5 inches of rain.

September—warmer and drier than average, especially if the earlier months have been cool.

October—same as September. It is usually in cold, backward seasons that September and October have any great significance. Dry weather in October helps the quality of corn and enables it to grade sooner than it would otherwise.

No temperatures above 96° in the heat of the day at tasseling time; ground thoroughly saturated with moisture during the twenty days following tasseling.

IDEAL WEATHER FROM THE CORN FARMER'S VIEWPOINT

This discussion applies particularly to south central Iowa but with certain modifications would hold for the entire Corn Belt.

January. A deep freeze in the soil in January is one of the things that makes the corn grower happy. The freezing breaks up the clods left by fall plowing. Any unusual packing by machinery or livestock previous to the freeze will not be serious the following year. Also, a deep freeze means that manure may be spread on the field without any damage to the soil because of packing. Any pasturing of livestock will not pack the ground while it is frozen. The frozen soil does not erode to any great extent either from wind or from water.

The thousands of insects and the dozens of corn diseases which are prevalent in the Corn Belt cease to thrive and multiply in the frozen ground. Many of them are killed, even in cribs and seed houses, and both insects and disease growth are retarded in their development. Snow on top of the freeze has certain advantages, particularly if the moisture content of the soil is low. Snow even on dry frozen ground melts slowly and part of it goes into the ground.

The average Iowa temperature for January is about 19° F.

February. February weather includes freezing temperatures and snow, which have a continued beneficial effect.

The average temperature is about 23° F.

March. In Iowa, March weather means rain, thaw, freeze, and high humidity. If the rain comes gently and in small quantities, the corn grower is pleased. If it comes an inch or more at a time it may cause damage from erosion. The soil loses the rigidity caused by the freeze and is subject to water erosion just as fast as the frost comes out. March is not neces-

sarily a good month for corn soil. Often the livestock are still on the field. They tramp the wet soil and destroy part of the benefits of the winter freeze. Trips to the field with the manure spreader may pack the ground. Not all the frost will be out of the soil in central Iowa in March.

The average temperature for Iowa for March is about 35° F.

April. In April the farmer thinks about field work. The frost is usually gone from the ground. Small grain is planted as a nurse crop for the legumes, which are a part of a following corn crop. This means more corn. April is the time of possible heavy rains, nicknamed "gulley washers" and "trash movers." Such terminology means that the water comes rapidly, moves a lot of soil down the hill, and takes any loose humus along with it. A heavy rain that comes rapidly removes a part of the beneficial effects of the freezing. Heavy rain makes plowing more difficult and causes delays.

Corn growers always agree that if the ground is well plowed seed corn may be put in the ground some way, somehow, in sufficient time to grow a good corn crop. Farmers consider early spring plowing and fall plowing both as better seed bed preparation practices than late spring plowing.

If April is unusually dry following a previous April that was unusually dry, the corn grower thinks about grasshoppers and chinch bugs. There has to be a supply of adult chinch bugs and grasshopper eggs from a previous season, or it is impossible for these insects to multiply in sufficient numbers to be serious. Insect-wise corn growers prefer a few hot murky days in late April when the humidity is high and the temperature even up in the nineties. This kind of weather helps eliminate the chinch bug and is not very healthy for young grasshoppers. April is one month of the year when a good corn grower likes to see some wind, not a wind of high velocity, but still more than a breeze. Any excess moisture on the top of the ground or near the top of the ground will travel off with the wind. This shortens the waiting after a rain, before returning to the field. This hot weather in late April may also

have something to do with cutworms and all the other insects that winter in the ground. They arrive at the active stage ahead of the corn crop and are not exactly timed with the calendar and the corn planter.

An average temperature of 48° to 49° for April is satisfactory. No farmer would object if it were a little warmer. The average rainfall in Iowa for April is 2.72 inches. That is just about right, if it doesn't all come in two days.

May. May is the important month for corn. The mean average temperature of the soil during May in Iowa is about two degrees warmer than the air. The soil does not get so warm in the day as the air; neither does it get so cold during the night. Corn is planted the first ten days in May, weather permitting. It may be too cold for planting corn and the soil may be too wet for field work. Again the corn grower wants to see some hot days with high humidity. That kind of weather brings the cutworms to the top of the ground and pushes up any planted corn.

Every corn grower dreams about planting corn with a perfect seed bed where there are no weeds and no weed seeds, no mud and no clods. The best the corn grower may hope for is sufficient moisture and heat to sprout the corn immediately after planting and no rain until the corn is up. If there is no rain, the small weed seeds that are close to the top of the ground do not germinate promptly. The ground is still loose and if it is just touched with the harrow or the weeder all the little weeds are destroyed and a new supply must sprout.

Some day in May there is a critical time for the European corn borer. The corn grower does not know just exactly what the reason is. It may be heat, rain, or wind, or a combination of these. The corn grower knows that some combination destroys millions of borers just about as soon as they are hatched and before they get inside a cornstalk. Every corn grower would like to have weather that would destroy a maximum number of corn borers, even though no scientist and no corn grower is yet sure just what kind of weather that is.

The average temperature for May is 60°, and the average rainfall is 4 inches. Most corn growers consider the 60° temperature satisfactory. They probably would like less rain. Anything more than 4 inches interferes with prompt corn planting.

June. A wet June means weedy corn and reduced yields. A wet, cold June causes slow growth. This postpones maturity in August and September. Sunshine, moisture, and a temperature above normal are great boons to the corn grower. If weeds are under control, so much the better. Corn does not need a lot of moisture in early June. Corn breeders usually agree that maximum growing conditions for June produce better seed corn, not only by hastening maturity in the fall but also by aiding detasseling. If the corn made more than normal growth in June, the tassels have a tendency to appear before the silks come out of the shoots. Furthermore, the tassels appear before they shed pollen and may be plucked without any fear of contaminating silks that have not yet appeared.

The average June temperature is about 70°, and the average rainfall is nearly 5 inches.

July. July sees the finish of cultivating the corn. It is the month when corn begins to blossom. In July the seed producer knows whether he has pollen on pollen rows at the time the silks appear on the seed rows. In this month the corn needs moisture. Central Iowa farmers would like to see 4 inches of rain in July, not in big heavy downpours, but several showers from ¼ to ½ inch. July sees the work beginning for all corn geneticists. They work with pollen and the silks. July is the time when one grain of pollen touches one silk and develops into one grain of corn. That is, all these things happen if July does not have an excessive temperature above 100° F and a deficiency in moisture.

A July temperature of 74° or above for an average seems to be pretty good. Bumper crops are grown in Iowa with that temperature. Average moisture is just short of 4 inches and is a part of the process which makes a good crop.

August. In August, the geneticists are still in the field. The later fields of corn are still pollinating. Heat and moisture together are necessary for maximum corn growth. An average temperature of lower than 75 degrees average in central Iowa delays the development of the corn and hence causes a higher moisture content later in the season. Breezes in July and August are desirable. High winds and hail never belong in the corn grower's weather dreams.

The average August temperature in Iowa is 72° F, and the rainfall 3.6 inches.

September. In September leaves on the corn in the fields are turning brown. If the weather has been favorable so far, corn has reached the stage beyond denting by middle or late September. Certainly a continuation of some of the moisture that was needed in July is useful in early September. In September the grower likes to see some warm weather, even above the average of 64°. Along with this kind of weather the corn grower likes to see a brisk breeze each succeeding day, adding to the potential corn crop. Such weather before any frost discourages molds and hastens the departure of moisture from the crop. The corn grower likes to believe that, as the moisture is leaving the corn plant, it is carrying plant food up the stalk and depositing the nutrients in the ear. On the other hand a wet, moist, cold September encourages the development of molds and delays the drying process, and the corn that grows until September 30 is still green and still high in moisture. At this time corn growers in central Iowa would like to have the moisture content of corn somewhere around 30 or perhaps 35 per cent, but not any more.

The average September temperature in Iowa is 64° F with 3.8 inches of rain.

October. Every corn grower in central Iowa expects a frost in October. A light frost stops photosynthesis in the leaves and is considered an advantage to corn. Even though such a frost may appear a little early, corn probably seems to suffer

TABLE 19

TEMPERATURE AND PRECIPITATION, POLK COUNTY, IOWA, 1946 *

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov	Dec.
Temperature												
Average	24.3	31.5	48.5	56.0	58.2	71.8	75.8	70.3	65.0	57.2	40.2	31.0
Departure from normal	+2.1	+6.6	+11.0	+6.0	−3.6	+0.7	−0.9	−3.7	−0.08	+2.9	+0.7	+5.4
Highest	51	65	80	83	83	97	98	95	91	81	65	69
Lowest	−7	6	12	31	32	44	57	45	37	33	17	−8
Precipitation												
Total	2.58	0.21	4.55	1.32	3.05	6.02	1.81	4.58	3.74	4.25	0.85	0.22
Departure from normal	+1.53	−0.89	+2.77	−1.24	−1.03	+1.61	−1.52	+0.78	−17	+2.00	−0.73	−0.90
Greatest in 24 hours	1.38	0.15	0.99	0.56	1.05	2.38	0.85	2.92	0.82	1.53	0.40	0.15
No. of days (0.1 inch or more)	7	5	17	7	13	9	9	12	10	5	8	4
Cloudy days	14	11	20	13	18	11	9	13	8	13	16	16
74-Year Mean—Iowa												
Average temperature	18.8	22.6	34.8	48.8	60.1	69.6	74.6	72.2	63.9	51.8	36.4	24.2
Highest temperature	72	80	94	99	111	111	118	116	107	97	86	74
Lowest temperature	−47	−41	−24	−8	13	27	35	30	15	−15	−25	−40
Average total precipitation	1.09	1.08	1.78	2.72	4.10	4.71	3.66	3.63	3.81	2.33	1.60	1.19
Cloudy days	10	9	11	10	8	6	4	5	8	8	10	12

* U. S. Department of Commerce, Weather Bureau.

more damage than is really the fact. The juices in the stalk still pass up to the ear where the moisture disappears. The dry matter in the ear increases.

The corn grower likes to see a breeze, and he would prefer a temperature above 52°, which is average. Most certainly he is not interested in a minimum of −15° which occurred in Iowa in October 1925. Seed corn growers watch closely the minimum temperatures that appear during October. There is a definite relationship between good seed corn and October temperatures. October temperature of below 25° for ten or twelve hours or more can definitely affect a wide area of commercial corn the following year. The seed corn producer breathes easier about October freezes when the preliminary moisture test from the field indicates that the seed corn contains below 25 per cent moisture. If the moisture is 30 per cent or more, every effort is exerted to get such seed to the drier.

The average Iowa temperature is 52°, and the rainfall 2.3 inches.

November. The major portion of Iowa corn is harvested in November. An atmosphere of low humidity with wind and no rain is the kind of weather the corn grower likes for November. If corn comes to the crib with about 22 per cent moisture or less, it should have somewhere between 16 and 19 per cent during the winter or spring.

The November average temperature is about 36°, and the rainfall 1.6 inches.

December. December may be cold or it may be wet, yet the corn grower prefers that, when he turns his livestock into the field, the soil should not be muddy. He also would like to have an opportunity to scatter barnyard manure on a field that isn't muddy. However, December is probably one of the least important months for corn, as far as weather is concerned.

The average December temperature is 24° and the rainfall 1.2 inches.

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CHAPTER XIX

GROWING, HARVESTING, AND PROCESSING SEED CORN

HYBRID SEED CORN GROWING

For convenience, we shall term the farmers who grow the seed corn, growers. These growers are selected by the hybrid seed corn company which is interested in the production in that particular area. The company furnishes the parent seed that is needed for growing hybrid corn. The number of varieties that are produced is controlled by the single-cross seed that is furnished to the grower for the production of double-cross seed, generally called hybrid seed corn. The corn is usually planted two rows (male) to furnish the pollen and six rows (female) to be detasseled. The six detasseled rows are harvested as seed corn. Sometimes this planting is by two rows and four rows, sometimes by two rows and eight rows.

The company may supply to the grower two different kinds of seed for crossing, one of which may be a short-season or early corn, and the other a long-season or late corn. The early corn may have to be planted from a week to eighteen days later than the corn requiring a long growing season. This arrangement requires more work and more attention on the part of the grower. In order to have the pollen from one parent fertilize the silk on the other, it is important that both blossom at the same time. The seed company must know how many days are required after planting for the early or short-season corn to arrive at the silking and detasseling stage. The same is true of the time required for the long-season or late

corn. The two corns must be planted on dates that will ensure silking and tasseling at almost the same time for the two kinds. An additional premium is paid to the grower for planting his corn at two different times.

There is usually a premium clause in the contract which makes it possible for the grower to enjoy a greater return on his crop than would be possible in growing market or feeding corn. The contract usually stipulates that the grower shall have assistance at the time of planting by someone who knows how the corn should be planted. The company also takes the responsibility for detasseling the corn at the proper time.

In calculating the number of bushels that the grower delivers, it is necessary to use a table that is fair to the grower whose corn has a moisture content even as high as 50 per cent. The experiment station at Iowa State College, Ames, Iowa, has determined how much 15 per cent dry corn is contained in 100 pounds of seed corn at harvesting time. (Table 20.) Seed corn may carry moisture up to 35 to 40 per cent, or even more, at harvest time. The following three statements are accepted as a basis for the figures in Table 20.

TABLE 20

CONVERTING WET CORN TO DRY CORN EQUIVALENT

Amount of Moisture	Weight per Bushel
per cent	*pounds*
15	67.89
20	73.96
25	81.25
30	88.50
35	95.71
40	103.16
45	110.88
50	118.14

1. The moisture content of kernels and cobs is equal when ear-corn moisture is 12 per cent.

2. The ratio of dry weight of cob to dry weight of grain is essentially constant throughout the grain moisture range of 10 per cent to 40 per cent.

3. The shelling per cent is 82.7, a value which gives 56 pounds of grain of 15.5 per cent moisture from 65.06 pounds of ears of 12 per cent moisture.

No. 2 dent corn contains on the average about 15.5 per cent moisture. Since it is customary to figure that a bushel of ear corn weighs 70 pounds, the weights of ear corn in Table 20 are needed in order to have a dry weight equal to a bushel of No. 2 ear corn.

Isolation. All seed fields are protected on every side against foreign pollen from other fields of corn. The most common required distance is 40 rods. Sixteen pollen rows may be planted along the side if the field is adjacent to another corn field. If there is a distance of 20 rods, eight pollen rows may be planted along the side.

Many states have an association of corn growers. This association may have a committee selected from active members to decide the distance between one corn field and another, if one field is producing seed corn. The distance is usually reduced if a specified number of pollen-bearing parent corn rows are planted along the edge of that portion of the field nearest to another corn field. These rules of isolation vary from state to state. The rules are sometimes taken as bona fide rules; other companies take them as suggestion and follow them to the letter or not, according to their individual judgment and desire.

Specifications for certified seed corn production require that any field at any time must not have excess pollen shedding from the female (seed-bearing) rows. The certification specifications for detasseling are different in different states. Such rules are usually written by the association of seed growers with the cooperation of the state experiment station. Copies of such certification specifications for any state may be obtained from the state experiment station. Inspectors employed

by the association try to visit all seed corn-producing fields during the detasseling period. The dates for visits are not announced in advance. The report of the inspector pertaining to the number of female tassels shedding pollen usually stands. Occasionally an appeal by the seed corn grower to the state association is submitted. It should not be assumed that all "seed fields" are growing certified seed. The certification requirements are a maximum in perfection. Many seed corn growers do not apply for certification yet comply in a general way with the certification requirements.

The seed corn company usually does the detasseling. Most of this work of actually pulling tassels is done by hand. Before 1941 much of the detasseling was done by college men and high-school boys, during summer vacation. Some younger men from farms found time during July and August to supplement the supply. Since 1941 the labor has been supplied by high-school students, both boys and girls, and by women who took some time from other employment and housekeeping to earn outside money. Perhaps there may have been more than a few women who did the work in part for patriotic reasons. In addition, other groups supplied some labor needs. Prisoners of war, Mexican nationals, and men from the Bahama Islands and Jamaica were used more or less in all areas where extensive hybrid seed corn was grown. In most fields a satisfactory job of detasseling was accomplished.

The actual job of detasseling in one field lasts from ten days to three weeks. Very careful work requires that the field be gone over every day, less careful work requires every second or third day. Late in the season, trips through the field may be from two to four days or more apart. The actual job of pulling tassels means that every tassel on each corn plant in the female rows has to be removed. The total 11,000 to 13,000 plants per acre require from seventeen to twenty-five hours per acre, depending on variety, weather, and all the human factors involved in a short-time, big job. Not all tassels appear the same day, and not all plants bloom at once. The tassel must

be pulled after it appears and before pollen shedding begins. This accounts for the repeated detasseling of the same field. The work is done by groups. Each group is under the direction of a foreman. These groups may include from five up to thirty or forty people.

There have been some detasseling machines. In the main these machines are transportation for the people who are pulling tassels. The machines, equipped with an automobile engine, are built high to clear the tall corn. The driver regulates speed according to the amount of work to be done. As more tassels are ready to be pulled, the forward movement is slower. Four rows or more are worked on one trip through the field. The number of tassels pulled per person per day is greatly increased with the use of the machine. Careful accounting shows no great economic advantage in machine detasseling. The overhead of the machine, including initial cost, repairs, and driver's time, reduces its actual usefulness. When the tassels are about all pulled, the machine declines in economic value. Heavy continued rains almost eliminate the use of the machine.

There have been attempts made to remove the tassels mechanically, but these attempts have not been successful. Corn is not all the same height in the same field, or even in the same hill. If all tassels could be removed at once, perhaps mechanical pulling would succeed better.

There is a small reduction in yield when the leaf area of a corn plant is reduced. Careful data collected over several seasons indicate that removing one leaf from every plant when the plant is detasseled by hand reduces the yield about 2 to 3 per cent. Removing two leaves reduces the yield about 4 to 6 per cent.

The grower does all the normal operations that would be necessary to cultivate the corn and to protect it from livestock. Often the seed company carries hail insurance on the crop. Some growers assume part of the expense of the insurance. The grower is compensated by the company at the rate

of so much per bushel for corn delivered to the seed house at harvesting time. If for any reason there is considerable hazard involved in growing seed crosses, the company may agree to buy the crop for cash at so much per acre, and the final settlement is made on a per acre basis and not on a per bushel basis.

Seed corn harvesting in the central Corn Belt of the United States usually begins in October. Some seed houses begin late in September, and it may be necessary to extend the harvesting time into November if the volume is too large for the seed house facilities, or if the weather interferes with continuous harvesting in October.

Part of the corn that is delivered to the seed house is not suitable for seed corn. Some contracts are so written that the grower is required to return this unsuitable corn to his farm. In other contracts the company pays for all corn delivered to the seed house.

Unless otherwise stipulated, the pollen-bearing rows are the property of the grower. He is, however, expected to use this corn for commercial corn purposes and not to dispose of it where it might be used in growing seed corn.

HARVESTING SEED CORN

Seed corn is not harvested as it was prior to 1940. Previous to 1940 a very great portion of seed corn was harvested as it had been since the days of the Pilgrim Fathers in New England. In recent years, harvesting seed corn has become big business. It is produced and processed in volume sufficient to supply about 70 per cent of the entire annual seed corn needs of the United States. Approximately 60,000,000 acres are planted to hybrid corn. The total United States corn acreage is 93,000,000 acres. To plant that much acreage requires about 8,000,000 bushels of hybrid seed corn.

It is well to observe that the use of hybrid seed corn is increasing year by year. During the past years the demand for

and use of hybrid seed corn has increased from 7 per cent in 1937 to approximately 80 per cent in 1948. (See Fig. 4.)

Seed corn is harvested by machinery. The most popular type of machine for harvesting seed corn is a two-row mounted mechanical corn picker. The mounted corn picker which really pushes ahead of the tractor is more satisfactory for hy-

Fig. 43. Field for production of hybrid seed corn. Six adjacent rows (female) have been detasseled. Two rows (male) were allowed to shed pollen.

brid seed corn harvesting than is the other machine, called the pull type.

With the mounted type of picker, the wagon follows the machine, and hence it is possible to harvest two rows at a time without disturbing the corn on either side.

Seed corn fields are usually planted two rows to furnish pollen and four, six, or eight rows to bear the seed corn. The rows that bear the seed corn are detasseled at the proper time. The two pollen rows are usually left until after seed corn harvesting time and allowed to dry on the stalk. The great

bulk of the seed corn is harvested with a moisture content of 25 to 35 per cent.

Harvesting in any area usually begins about 30 days earlier than the first killing frost for that particular area.

The mechanical corn pickers for harvesting seed corn usually have some modification on the snapping rollers, and some

FIG. 44. A mechanical corn picker which cuts the stocks loose from the ground, delivers the ears to the trailer wagon, and shreds the fodder before spreading it on the ground. This type of machine is effective in destroying most of the corn borers which are in the stocks that are shredded. The illustration shows the machine without the snapping rollers and husking attachments, harvesting sweet corn for canning.

of the commercial machines allow for other adjustments in other parts of the machine. These changes or adjustments are made in order to avoid any unnecessary damage to the seed. Some machines are driven at a slower speed for the same reason. Any field that shows up along the roadside in the fall with two rows still standing at regular intervals and the other rows already harvested may be identified as probable sources of hybrid seed corn.

The corn is usually grown around some town in which a building is located for preparing the seed for the next spring's

planting. This building is known as the seed house. The corn usually is grown within a radius of 20 miles of the seed house. Less distance is desirable; more distance sometimes is practical. When the wagon behind the picker is full of corn, it may be unloaded in the field into a truck and the truck goes to the seed house, or the wagon itself may take the load. At the seed house a hoist lifts the front end of the truck or wagon, and the corn pours out onto a moving belt. This belt carries the corn into the seed house.

Husking and sorting. The corn comes off the belt onto what is known as husking rollers. These rollers are patterned after husking rollers that are part of a corn-picking machine. They are usually in pairs with the corn on top. The rollers operate like the rubber rollers on a clothes wringer. The husks go through the wringer, and the corn stays on the top side. By the time the corn arrives at the lower end of the husking rollers, it is almost free of any shucks or silks which were delivered with the corn. From this husking roller the corn goes to the sorting belt. These sorting belts or tables are so arranged that workmen stand on one or both sides and use their judgment to select desirable corn for seed.

There are two methods of sorting corn. In one, every ear of corn is picked up and individually inspected. The person doing the sorting removes any damaged or undesirable kernels or removes the entire ear if it is diseased or if the ear is not uniform in color or ear type as compared to the rest of the seed. By this method the good corn is taken off the belt and the objectionable corn rides on to the discard pile. If sorting is done on the table, the good corn is taken off the table and the undesirable is pushed off to the discard.

The second method of sorting corn is from a moving belt. The workmen stand on either one or two sides of the belt and select from the belt the ears they see which are undesirable for seed corn. Thus only the undesirable corn is handled. The total seed corn that is inspected by one man in a day is con-

siderably more with this method than it is with the first method.

After the corn has had the silks and shucks removed by the husking rollers and has been inspected by the men who do the sorting, it is delivered by basket, belt, or elevator to drying bins.

Drying. The drying process involves the use of artificially heated air, forced through the corn that has been piled up as in a corn crib. These drying bins are usually made with a lattice bottom. The more satisfactory ones have two floors, a cement floor on the ground, and a slatted floor, 2 feet or more above the cement floor. The slatted floor may be made out of 1 by 4 inch boards placed on edge ⅞ inch apart. This slatted floor is sloped to one side of the bin to aid in emptying the bin. The heated air is delivered to the underside of the slatted floor. The sides of the seed bin are airtight. There is no escape or forward movement of the air out of the bin, except through the corn. The corn may be from 7 to 12 feet deep. Some seed houses are so designed that the heated air which has been coming through a bin that is almost dry may be delivered to another bin that is beginning the drying process. Other seed houses are so constructed that heated air may be reversed in direction and delivered to the top of the corn and forced down through the corn and out through the slatted floor. The air is then either released or returned by means of tunnels and forced through the second bin.

The source of the hot air is a furnace. The fuel is oil, gas, or coal. The most common fuel is oil. The air is forced through the corn by a fan, known to the trade as a multivane fan. The power to drive the fan may be electricity, tractors, steam engines, or stationary gas engines. One commercial company has made most of the units for drying corn. Their units are usually placed on wheels and consist of an oil burner, an electric motor with 15 to 40 hp, and a fan. The fan is placed between the source of heat and the duct leading the hot

air to the corn. It sucks the heat, including the combustion fumes, from the flame and delivers it into the tunnel.

The temperature is controlled by a thermostat which maintains an average degree of temperature of approximately 107° within the corn bin. Some operators use 115° or perhaps more. During the processing season these drying units run twenty-four hours a day, seven days a week. Careful managers insist on having an operator on duty for every burner, every minute it is in operation.

By increasing the temperature, the rapidity of drying is greatly increased. As the temperature is reduced, the drying process consumes more time. Correct drying temperature control is determined by how much heat the corn will stand without reduction in germination. Experimentation has definitely shown that corn with high moisture content is more sensitive to either cold or hot temperatures than dry corn. Also, the heredity of the corn makes some difference in how high a temperature may be used in drying.

The majority of the seed houses must choose between high temperature and possible damage to the germination of the seed corn, as against a lower temperature and no damage to the seed from the standpoint of heat applied. The higher the temperature, the more corn may be dried in a given length of time. Lower temperature means reduction in volume of corn processed.

Corn delivered to the drying bin with 35 per cent moisture and exposed to moving air at a temperature of 107° requires from seventy-two to ninety hours' drying time. This should reduce the moisture content of the corn to approximately 13 per cent. The variables within the drying process are several. One is the percentage of humidity in the air that day; another is the amount of air moved through a given quantity of corn; and another is any necessary interruption of a continuous uniform temperature and air volume for the entire drying period. Corn that is put into the drying bin with about 25 per cent

moisture will be reduced to 13 per cent moisture in approximately fifty to sixty hours.

The seed house operator likes to use his drying bins to the best advantage and may want to go to the sheller with his corn as soon as possible after it is dried. Some operators blow air of outside temperature through the corn before they shell it; others let it stand in the drying bin for twelve to twenty-four hours or more to cool. Those who have had considerable experience in storing shelled seed corn prefer to have the corn cooled before it is shelled.

Shelling. The advent of hybrid seed corn produced in volume by technical methods has changed the method of shelling seed corn. In former days and even yet in areas where hybrid seed corn is not grown, seed corn may still be shelled by hand. A machine, however simple, is not used. In other areas, 1 to 100 bushels may be shelled with a small machine sheller where the power is furnished by the operator himself or by an engine or small electric motor.

Hybrid seed corn is shelled by machinery. Shellers are designed to shell market corn rapidly. The shelling capacity of these commercial shellers ranges from 200 bushels up to 5000 bushels per hour. These shellers may or may not be altered or adapted to the particular job of shelling seed corn. The shellers may be driven at a slower speed for shelling seed corn than for market corn. Also a sheller may be adjusted to avoid undue pressure on the corn while shelling. There are no shellers on the market especially made for shelling seed corn.

Sizing seed corn. The term sizing, applied to seed corn, means mechanical sorting for size and shape of kernels. The great bulk of seed corn is sized into six different sizes, three flat and three round. There are large flat kernels, which are regular in shape, of uniform thickness, of uniform width, and with little variation in length. Medium flat kernels are similar in shape but smaller than the large flat kernels. The small flat kernels are also regular in width and thickness; perhaps a little more irregularity in length may be permitted, but for all

intents and purposes they are a smaller kernel of the same shape as the two previously mentioned. The round kernels are not round but irregular in shape. Large round kernels are usually the same width as large flat kernels, the difference being that they are thicker. The medium round kernels are approximately the same width as the medium flat, and again the chief difference is that they are thicker than the flat kernels. The small round kernels are thicker than the small flat kernels; some are almost the shape of an egg with a point on one end.

Seed corn producers prefer to offer a maximum amount of medium flat kernels. By care in breeding and growing corn, and by adjusting the sizing machinery, it is possible to arrive at the end of the season with from 40 to 50 per cent of the entire corn crop being designated as medium flat. Some seed corn producers number the size of the kernels according to the size of opening in the separating screens that are used in the sizing process.

The percentage of flat kernels may be increased if the percentage of long ears is increased. Corn may be bred to produce longer ears and hence a greater percentage of medium flat kernels. Again it is possible to breed corn with nearly all irregular kernels, in which case the percentage of medium flat kernels would be reduced. The emphasis is on breeding corn that has continuous regular rows of kernels from end to end of the cob. The percentage of flat corn is considerably more than in corn that inherits irregular spacings of the kernels on the cob.

Complete pollination produces more maximum flat kernels, assuming that other conditions are favorable. Corn that is grown on ground with high fertility has a tendency to produce larger ears and more uniform ears and hence a large percentage of desirable kernel shapes. A favorable growing season has its influence on the size and shapes of the kernels. A dry season or a drought produces more small round kernels instead of medium flat kernels. The growing season of 1945 in Iowa

was cold early in the season and corn matured late. This immature corn produced a bigger percentage of small kernels of all shapes than did corn of identical breeding grown in 1946. The excessive rain followed by drought in much of the Corn Belt in 1947 produced smaller seed corn kernels with an abnormal quantity of round kernels. In making his crosses of inbreds a corn breeder also needs to watch that his crosses in the final product for seed do not inherit a kernel characteristic that is not suitable for desirable sizing.

Sizing is done by passing the corn over perforated screens. If the screens have round perforations, the smaller, narrower kernels go through. If the screens have elongated, narrow, long perforations, the flat kernels go through. The material that makes up these screens is either steel or zinc, and the perforations vary $\frac{1}{128}$ inch from one size to the next. In actual practice, a screen that is called a #17 round has holes that are $\frac{17}{64}$ inch in diameter. A #16½ screen actually has holes that are $\frac{33}{128}$ inch in diameter, and a #16 screen has holes $\frac{16}{64}$ or ¼ inch in diameter. Similar measurements refer to the width of the elongated perforations.

Calibration. The term calibration, in the seed corn industry, has to do with corn planter plates. A different corn planter plate is required for planting almost every size of kernel offered for sale. Seed corn producers recommend to their customers a corn planter plate that will plant corn three kernels to the hill. The customer may look at the information on the seed corn bag and select readily the plate needed for his corn planter in order to secure a satisfactory number of kernels per hill.

Treating and sacking. Almost all seed corn that is prepared by hybrid seed producers for planting is stored and sold in bushel bags. The most popular material is closely woven, strong, cotton cloth. These bags are made by bag manufacturing companies, who furnish them at so much per thousand for the various corn-producing companies. The bags are usually printed with the trade name of the corn producer. Until

the advent of hybrid corn, there were no bags on the market made specifically for seed corn. The bags are of proper size to hold 56 pounds plus a few ounces of shelled corn. The standard size of the original piece of cloth which is sewed on two sides to make the open bag is 30 by 35 inches. The finished bag is about 29½ inches deep and 33½ inches inside circumference.

Seed treatment. Seed treatment means applying a chemical compound to the surface of the seed. Usually the carrier of the chemical compound is some inactive substance. The most common active ingredients are mercury ethyl phosphate $[(Hg(E_2H_5)_2PO_4)]$, tetramethyl thiuramdisulfide $[(CH_3)_2$-$(CNS_2S_2)]$, and tetrachloroparabenzaquinone $[C_6Cl_4O_2]$. These compounds all appear on the market under trade names applied by manufacturers.

The number of new fungicides now available in the open market are increasing rapidly. Some of the later-developed fungicides form a film covering the entire seed. The demand for fungicides that will adhere to the seed coat of corn kernels is increasing. Also there is a desire and a demand for fungicides that are not poisonous or irritating to workmen and livestock. Some new fungicides show marked improvement over the older ones in both seed protection and absence of poisonous and irritating qualities.

These dusts are applied to the corn by thoroughly mixing about 2 ounces of dust with 56 pounds of corn. Half or more of the dust will cling to the seed corn. If the seed happens to be a little rough, scuffed, or cracked, it seems to pick up more than its actual share of the dust. There have been some attempts to apply fertilizers, in small quantities, directly to the seed.

Fungicides have their value after the corn is planted and before the corn has time to germinate. A kernel of corn is alkaline in reaction if it just takes up water and doesn't sprout. In such a state it is a good culture medium for various molds and corn diseases which are usually present in ground that has

been previously planted to corn. Most of these molds and diseases thrive readily in a temperature between 40° and 50° F, when the soil is wet. They attack the kernel after it has taken on moisture but has not yet germinated. A kernel of dent corn does not germinate very rapidly until the temperature of the soil gets above 60°. If the weather is unduly wet and maintains a temperature of below 55° for several days after the corn is planted, the protecting film supplied by the chemical attached to the kernel is a great help in retarding the growth of molds and corn diseases which attack a kernel of corn in the ground. During this period in the cold wet ground, some of the starch and sugar is removed by solution into the soil.

Very shortly after the kernel of corn germinates, the chemical reaction changes from alkaline to acid, and the kernel is not a satisfactory medium for the growth of molds and diseases which made the attack previous to germination. Herein lies the reason for not scuffing or cracking the kernels. Sound kernels do not depend nearly so much on treatment. Not all seed corn producers treat seed. When seed corn is planted and the temperature remains at 60° or above, corn germinates promptly, leaving a minimum opportunity for attack of molds and diseases. Flint corn germinates at a temperature as low as 42°.

Carry-over seed. Corn that is retained by the seed corn producer until it is more than a year old is called carry-over corn. This carry-over corn is insurance against an exceedingly short seed-producing crop in any year, or even against a near crop failure in seed production. The yield of seed corn per acre may vary as much as 50 per cent from one year to the next in the same area. If the producer has a uniform demand for a certain amount of seed corn, this variation means that he has excess corn one year and probably not enough another year. If the carry-over corn has a moisture content of 6 to 10 per cent moisture and is sealed in airtight containers, it retains its germination rather well during the summer and second winter season. If it is placed in waterproof containers and stored in

a temperature of 35° to 36° F, it also retains its ability to germinate. First-quality seed corn stored at room temperatures (not in steel buildings) may be carried over and still retain 90 per cent or more of the original percentage of germination. Corn that germinates well produces a good crop. Seed corn men and farmers object to old seed corn. Their objection is based on long-time experience with open-pollinated corn. It is hardly fair to compare excellent hybrid seed corn that has been properly dried and stored to the former open-pollinated corn that was not given the advantage of careful storage for carry over for next year's seed.

It is well to bear in mind the importance of having sufficient seed available every year to plant a desired acreage in any given state or area. The choice must be made between carrying over some seed or growing enough to supply the entire seed demand in a season when the seed corn crop may be the minimum. The minimum seed corn supply may be 20 per cent or more below the average yearly demand. The problem of carry-over seed corn has increased as the saturation point has been reached for the use of hybrid corn throughout the Corn Belt. There is no supply of open-pollinated corn adapted to fill the demand if hybrid seed corn should not be available.

Hand-harvested seed corn. Open-pollinated corn still supplies the seed that plants about 20 per cent of the acreage of the corn in the United States. Part of this seed is furnished by seed houses who still offer open-pollinated corn for sale. The selection may be made in the field, one man carrying a sack over his shoulder, examining each ear and stalk as he goes. He selects ears from healthy stalks that are themselves almost free of disease. This selection may be made before the corn is dry enough to keep without being dried. The seed may be selected at crop harvesting time or even at planting time from the corn crib.

Small quantities of corn are dried by hanging on the back porch or over the driveway in the corn crib, or they may be tied together by a few remaining shucks and hung up outside

without any shelter. This corn is usually allowed to remain there from harvesting time until the planting season arrives the next spring. The butts and tips are shelled off by hand as a substitute for sizing. Only those flat kernels in the middle of the ear are used for the great majority of hand-picked seed corn.

In the old days the careful farmers in the Corn Belt insisted that the corn they harvested themselves be shelled by hand. Perhaps there was some point in their emphasis on hand shelling, as no kernels were cracked or scarified.

GENERAL SEED CERTIFICATION STANDARDS

Type of certifying organization. Certification should be conducted by an incorporated nonprofit organization of seed growers, or a state or dominion agency. The organization or agency should be designated under state or dominion legislation and maintain a close working relationship among seed growers and agricultural research, extension, and seed regulatory agencies.

Purpose of certification. The purpose of certification is to maintain and make available to the public high-quality seeds and propagating materials of superior crop plant varieties so grown and distributed as to ensure genetic identity and purity. The word "seed" or "seeds" includes all propagating materials.

Eligibility requirements for certification of crop varieties. Only those varieties that are approved by the state or provincial agricultural experiment station and accepted by the certifying agency are eligible for certification.

Classes and sources of certified seed. Three classes of seed are recognized in seed certification, namely, foundation, registered, and certified. These classes of seed must meet the standards of the International Crop Improvement Association for the respective crops. The classes are defined as follows:

1. *Foundation seed.* Foundation seed, including elite in Canada, are seed stocks that are so handled as to most nearly

maintain specific genetic identity and purity and that may be designated or distributed by an agricultural experiment station. Production must be carefully supervised or approved by representatives of an agricultural experiment station. Foundation seed is the source of all other certified seed classes, either directly or through registered seed.

2. *Registered seed.* Registered seed is the progeny of foundation or registered seed that is so handled as to maintain satisfactory genetic identity and purity and that has been approved and certified by the certifying agency. This class of seed is suitable for the production of certified seed.

3. *Certified seed.* Certified seed is the progeny of foundation, registered, or certified seed that is so handled as to maintain satisfactory genetic identity and purity and that has been approved and certified by the certifying agency.

The certification tag which is attached to the bag serves as evidence of the genetic identity and purity of the seed.

The regular certification tag may be used for identifying all classes of foundation, registered, and certified seed. The word foundation or registered may be printed or stamped on the regular certification tag in case the seed meets the requirements of foundation or registered seed.

The following colored tags should be used to designate quality for registered and certified classes:

Blue tag for first-quality seed.
Red tag for second-quality seed.
Yellow tag for seed as described.

SEED CORN TESTING FOR VIABILITY

Most state experiment stations in the United States maintain what may be called a seed-testing laboratory. The services performed by such a laboratory include actually sprouting samples of seed corn to determine the percentage of viable seed in the sample. Several hundred seeds may be used in

making the test. The report is then mailed to the owner of the seed from which the sample was taken.

This test may be made by one of two general methods called "warm" and "cold" tests.

Warm test. The warm germination method usually means that the seed is placed on wet soil or sand, cloth, or blotter. The corn and the moisture-carrying material is then placed in a temperature conducive to rapid germination of the seed. After sufficient time has elapsed to allow all normal kernels to grow, the count is made for the seeds that have grown. If ninety out of every one hundred seeds grew, then such seed is referred to as having 90 per cent germination. Higher or lower percentages of growth may also be determined from samples. The percentage of germination is usually stated when seed corn is sold to the consumer.

Cold test. Cold germination is similar in procedure, except that the seeds on the moisture carrier are first placed in a constant temperature that may be as low as 40° F. The seed sample is left in this cold environment for three days or longer. It is then removed and submitted to a growing temperature similar to that of the warm test. Some kernels, that could make a satisfactory germination if placed in warm environment not proceeded by some days in a colder environment, fail to grow after the time period in the cold temperature. A contributing factor that increases the difference between the germination percentage of the warm and cold tests is the presence of molds and diseases which attack the kernels before they sprout. This damage is likely to be more severe in the cold test.

Rag doll. In former days corn kernels were placed on a strip of cloth. The cloth was then rolled, soaked in water, and stored in a room where temperature would be conducive to germination. This was known as the "rag doll" germination test.

New methods of testing for viability may or may not be widely used. Brief mention will be sufficient here.

Pink color salt method. Kernels of corn are soaked in lukewarm water for about twelve hours. The kernels are then split the long way and perpendicularly to the germ side. The plumule and radicle need to be split. These split kernels are

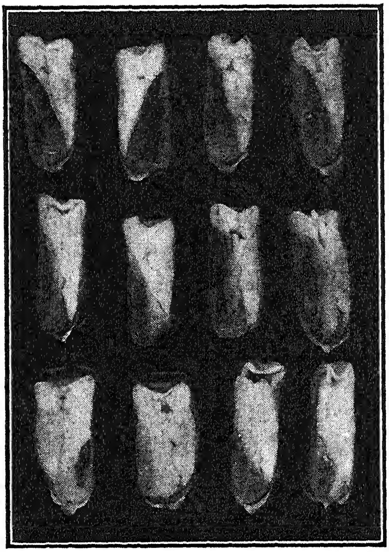

FIG. 45. In the pink color salt test, the four kernels at the top showed a uniform carmine red coloring for plumule, radicle, and scutellum. The other eight kernels did not show uniform coloring.

then placed in a weak, colorless solution of a salt, tetrazolium chloride. The action of this salt on living germs in the soaked split kernels turns the exposed parts pink in two hours or less. Dead kernel parts do not color pink. Corn kernels from the same soaked supply that have been boiled before being placed in the salt solution remain colorless. Germination tests by the usual methods indicate that the percentage of live kernels indicated by the tetrazolium method is somewhat higher than the percentage obtained in any other way.

Electrical method seed testing. When soaked corn kernels are placed between two electrodes in an electrical current, the

dead kernels allow less passage of current than do the live ones. The galvanometer must be sensitive enough to give readings in millivolts. The correlation of this method of learning the germination percentage and the usual method of germination testing indicates that the electrical method has possibilities. No extensive use has been made of either the pink coloring method or the electrical method.

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CHAPTER XX

HARVESTING THE CROP

STORING CORN ON FARMS

Corn cribs. A corn crib is a storage building, designed particularly for the corn crop. Permanent cribs are constructed of wood, tile, cement and steel; temporary cribs are constructed of wire, snow fences, or poles and woven wire. Floors in temporary cribs may be tile, wood, sheet steel, fiber roofing, or dirt.

Crib capacity. In general $2\frac{1}{2}$ cubic feet of space is necessary for storing 1 bushel of ear corn. Storage space required for ear corn with husks on is about $3\frac{1}{2}$ cubic feet per bushel. About $1\frac{1}{4}$ cubic feet is necessary for storing shelled corn. The U. S. Department of Agriculture, Production and Marketing Administration, has recommended the appropriate width of cribs for different corn-producing areas within the United States. These recommendations may be found in Fig. 46. A reference to this map will give a clear understanding of where the narrower cribs are needed and where wider cribs are satisfactory. It is well to note that corn cribs developed by practical farmers in Pennsylvania may be as narrow as 30 inches at the bottom and get wider as they increase in height. Before the advent of the U. S. Production and Marketing Administration practical farmers were using cribs as wide as 10 feet or more in the southwestern portion of the Corn Belt.

The permanent crib observed in the major portion of the Corn Belt is what is known as either a single or double crib. Single cribs have a specified width of 6 to 10 feet and are of any desired length, with the roof sloping in one direction. A

double crib comprises two single cribs with the high sides of the roofs facing each other. The roof is extended to a gable in such a way that the double crib is really one building with a passageway between the two parallel cribs. Double cribs

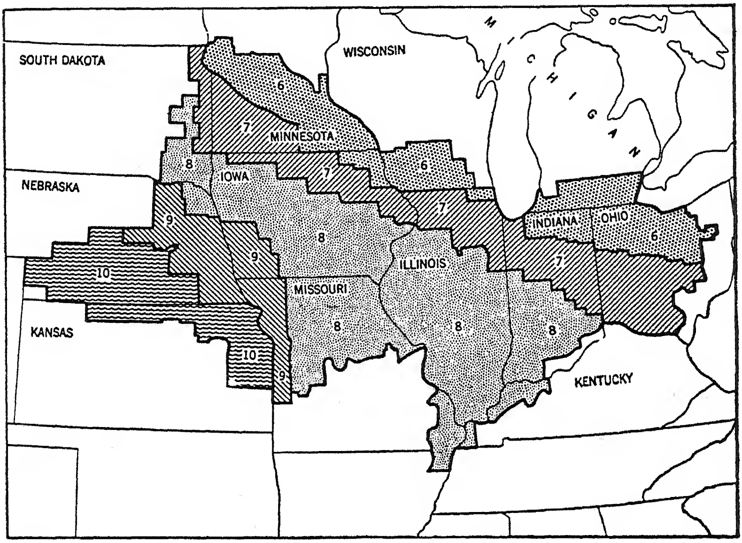

FIG. 46. The numbers printed in the shaded areas shown on the map indicate the recommended corn crib widths (measured in feet) for securing Commodity Credit Corporation loans on ear corn. Loans are also made on corn stored in round cribs. Recommendations for round cribs allow the diameter to be 50 per cent greater than the width of rectangular cribs in the same area.

Rectangular crib width in feet	6	7	8	9	10
Round crib diameter for same area	9	10½	12	13½	15

are usually higher than single cribs and are often equipped with inside ear corn elevators. Double cribs may be filled by means of outside portable elevators.

A corn crib should allow for ventilation and loss of moisture from the corn while it is stored in the crib. Storing corn in cribs usually begins in the Corn Belt proper in October. The

cribs in the Corn Belt were designed for storing corn when corn was gathered by hand and delivered to the corn crib from the wagon with a scoop shovel. One man would pick from 80 to 100 bushels per day. The corn had a chance to dry out somewhat before more was piled on top of it. The efficiency of the crib under such circumstances was increased tremendously. With the development of the mechanical corn picker a good operator can pick from 10 to 15 acres a day with a two-row mechanical corn picker. That is, he piles up in the crib from 600 to 1000 bushels or more in one day. This corn will probably have more shelled corn in it than will hand-husked corn, and it usually contains more silks and husks. After the silks and husks and shelled corn get into the crib they interfere with ventilation.

Permanent cribs. Most of the corn cribs in the Corn Belt are built of wood with cement floors. The strips of narrow lumber siding are put on 1 inch or more apart. The height of the older cribs was controlled by how far a man could throw corn into the crib with a scoop shovel when standing in a wagon. New cribs are much higher than old ones. In fact in some of the new cribs with outside elevators the corn may be 20 feet or more in depth. The average is 10 to 14 feet. Ear corn stored 20 feet deep is not an aid to ventilation. The corn at the bottom is under great pressure. (Twenty feet of corn weighs a minimum of 560 pounds per square foot of floor space.) This pressure helps to press the ears close together and reduce air space in the corn. A farmer says the "corn has settled." Cement blocks are made to substitute for lumber siding. They block free passage of air into the corn and yet protect the corn from the weather. Steel cribs are comparatively new. They have perforated sidings, and some of them have concave bottoms or floors, part of which is made with very strong hardware cloth.

Facilities for rapid emptying are often included in cribs of permanent construction. This is usually accomplished by some sort of drag ("drag line" or "shelling trench") to move

the corn towards the sheller with facilities for letting the corn pour on the drag directly from the crib.

In the southwest portion of the main corn-growing area, corn may be stored without a crib, just piled on the ground. Corn cribs in the southern part of the United States, east of the Mississippi River, are not likely to be very large. The corn is stored in these cribs with the husks on. The corn is snapped from the field and put into cribs. It is husked only as it is

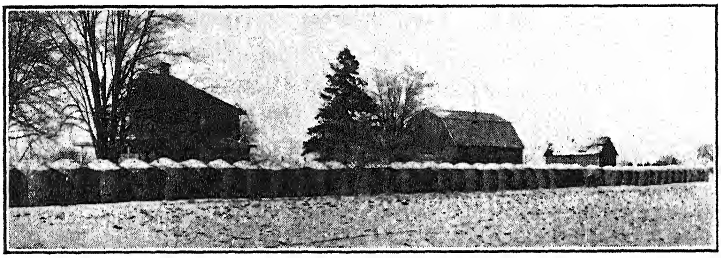

FIG. 47. Ten thousand bushels of corn in temporary snow-fence cribs.

needed. This custom seems to be followed because of the belief, based on long-time experience, that insects do not damage snap corn nearly so readily as they do husked corn in storage. Where zero weather is not experienced at any time during the year, the careful farmer takes greater precaution to control insects and keeps his crib clean, removing all the husks as they accumulate. In the area where snap corn is stored, very little attention is paid to excessive moisture within the ear. A great deal of attention is required to protect the ear against insects. The closer one approaches the tropics the greater the insect problem becomes.

Temporary cribs. Temporary cribs are made from woven wire or with picket snow fences for sides. They may have wood or tile floors, they may have fiber roofing spread on the ground for floors, or the corn may be piled directly on the ground. Temporary cribs may or may not have a roof. The U. S. Production and Marketing Administration recommends

roofing, particularly if the corn is to remain in the crib very long. If the temporary cribs are round, two-thirds of the diameter may be considered as equivalent to the width of a rectangular crib.

Elevators. Elevators are provided with a screen to allow the shelled corn to drop out before it arrives at the crib. This shelled corn may be hard to keep if it has more than 20 per cent moisture. If, however, it is put in the crib, an economic loss more extensive than the value of the shelled corn is possible. Ear corn is more likely to be properly ventilated if the shelled corn has been removed. Elevators are also equipped with a distributing spout. This distributing spout delivers the corn in several different places in the crib. The ventilating possibilities are increased if the spout empties against the side.

Rapid delivery by mechanical pickers requires more careful management in the crib. Also, the development of hybrid corn has increased the farmer's chances of getting a variety that will not mature. Corn that will ripen in northern Iowa in some seasons is likely to be entirely too late in other seasons. Before the wide distribution of hybrid corn, the local farmer selected his own seed from corn that was ripe, and he did not have the opportunity nor the invitation to buy corn that would probably yield more but mature later. This opportunity to buy later corn, which was made possible by the wide distribution of hybrid corn and rapid harvesting which can be accomplished with the mechanical corn picker, has reduced the efficiency of older corn cribs and required more attention to corn drying. The recommendations of the Production and Marketing Administration on crib widths is a recognition of this problem of drying corn in cribs.

Corn crib problems. Corn growers, dealers, and those who study corn storage on farms are all aware of the rapid changes in methods of breeding and harvesting corn. There still remains the problem of storing corn on the farm so that the efficiency of the crib is more satisfactory or at least as satisfac-

tory as were the drying facilities of the crib when the crop was gathered by hand.

Many of the present corn cribs were built for hand husking and shovel unloading. Several hundred bushels were not delivered to the same crib in one day. If our cribs were half the present width, certainly less mold would develop in stored corn.

The increase in the height of the modern crib increases the pressure on the corn at the bottom of the crib. This increase in pressure reduces perceptibly the opportunity for natural ventilation in the lower portion of the crib.

Additional opportunity for corn to dry may be supplied by temporary ventilators within the cribs. Metal, tube-shaped ventilators made of heavy hardware cloth have become common in the trade. These provide air space through the middle of the crib. They may run lengthwise or crosswise, or they may be vertical open shafts, in any kind of crib, including the temporary one.

Some corn is now being dried by artificial ventilation with ventilators and the forcing of heated air through the corn. Artificial drying of corn on farms is not extensively used but is on the increase. Wet-process millers do not find improperly artificially dried corn satisfactory for their purposes. If the temperature used in drying has been from 175° to 200° F, this excessive heat seems to cook the starch in the corn kernels. The cooked starch adheres to the miller's equipment with disastrous results. A comparatively small percentage of such improperly dried corn in a day's run causes great difficulty for the wet-process miller.

The early marketing of corn that carries a high moisture percentage is another outlet for the grower. Wet corn will not sell for as much money on the market, but the discount for a limited amount of moisture is pretty much in line with the increase in weight due to the high moisture. Corn may be gathered just as early as it will shell and shelled directly from the field and hauled to the elevator. The corn is not stored

on the farm at all, and the extra handling required to fill the crib and empty it again is eliminated.

A corn crib should protect the corn against the weather and permit it to lose moisture. Protection is also needed against rodents, particularly mice and rats. Rats usually are more plentiful if the crib floor is made of wood and is well above the ground. The rats work the dirt up into the corn and perhaps damage enough corn even to change the grade when it goes to market. The rats and the filth that is always present where they live reduce the feeding value of the corn even when it is fed on the farm. Cement floors with deep foundations prevent rats from working under the floor. Hardware cloth can be used inside wood sidings to reduce the opportunity for rats to obtain entrance to the corn crib near the bottom. Hardware cloth may also be used for the same purpose to construct cribs of cement or tile. Steel cribs are mostly ratproof. Poison may be used to control rats. There is now on the market rat bait which is poisonous to rats and is not poisonous to livestock. Traps may be used, but they are not very satisfactory.

CHAPTER XXI

FEEDING AND MARKETING CORN

Eighty to 85 per cent of the corn crop is fed to livestock. In growing corn, therefore, it should constantly be kept in mind that livestock, in all probability, will be the final market. The outstanding problem of the Corn Belt is to obtain the greatest possible number of pounds of livestock from each acre of land with the least expenditure of human labor. Any step forward which results in the economic production of more bushels of corn per acre is fundamental to solving this problem.

The rich soil and favorable climate which make it possible to produce corn more abundantly and cheaply in the Corn Belt than any place else in the world also make it possible for this section to produce fat livestock, especially hogs, more abundantly than any other part of the world. Fat, energy, and heat-forming materials can be produced in corn of the Corn Belt with less outlay of labor and power than in any other grain. (See Fig. 52, page 300.)

LIVESTOCK USE OF CORN

Balancing the corn ration. Although corn is the most important fattening grain, it has certain serious drawbacks. First, it is low in protein and ash-bone and muscle-building material. Second, the protein which it does contain is largely zein and other types of protein which are inefficient for muscle-building and milk-giving purposes, unless properly supplemented with feeds containing higher types of protein. Third, corn is relatively low in vitamins, except vitamin B. Yellow corn contains some vitamin A, but white corn contains none. At the Wisconsin Experiment Station it has been proved that, on good pasture containing plenty of vitamin A, pigs would

gain as well on white corn as on yellow corn. Tankage usually contains a little vitamin A but not enough to supplement the complete absence of this vitamin in white corn. This was indicated by a Wisconsin pig experiment in the fall, in which it was found that the "white corn" pigs during the winter required 489 pounds of white corn and 59 pounds of tankage to gain 100 pounds, whereas the "yellow corn" pigs required 439 pounds of yellow corn and 53 pounds of tankage.

Corn compared with other starchy grains. The average percentage composition of some of the common carbohydrate grains is shown in Table 21. This composition shows that corn, wheat, and rye each contain about 2 per cent fiber, whereas barley contains more than twice as much fiber as corn, and oats contain five or six times as much. For hogs, each 1 per cent of excess fiber lowers the feeding value by 5 per cent. Excess fiber is not so important with horses and cattle, and for this reason oats are much more efficiently utilized by this class of livestock than by hogs.

Table 21 shows the average number of pounds of digestible nutrients in 100 pounds of the common grains.

TABLE 21

AVERAGE COMPOSITION, DIGESTIBLE PROTEIN, AND TOTAL DIGESTIBLE NUTRIENTS OF SPECIFIED GRAINS AND BY-PRODUCT FEEDS *

Grain	Moisture	Protein	Fat	Crude Fiber	Ash	Nitrogen-Free Extract	Digestible Protein	Total Digestible Nutrients
Corn	12.9	9.3	4.3	1.9	1.3	70.3	7.0	80
Wheat	10.6	12.0	2.0	2.0	1.8	71.6	9.1	75
Barley	9.6	12.8	2.3	5.5	2.9	66.9	10.0	79
Rye	9.0	11.1	1.7	2.1	1.9	73.7	9.3	80
Oats	7.7	12.5	4.4	11.2	3.5	60.7	9.5	66

* Compiled from *Brewers' and Distillers' By-Products and Yeasts in Livestock Feeding*, U. S. Department of Agriculture, Bureau of Animal Industries, AHD 58, 1942.

Grinding corn. One great advantage of corn as a feed for hogs is that ordinarily it is not so necessary to grind it as it is

to grind most other grains. Numerous experiments have proved that with dent corn the most profitable results in hog feeding can usually be obtained with either ear corn or shelled corn. Shelled corn is often self-fed; ear corn nearly always has to be hand-fed twice daily to hogs. Flint corn usually needs to be ground for hogs. Hog raisers in Argentina have discovered that they could not build up a profitable hog industry until they substituted the softer textured dents for the hard flints. In Europe, Argentina flint corn is always ground before feeding.

To fatten steers, the practical plan is to feed the corn on the ear or shelled, if there are hogs following to pick up the corn, about 10 per cent remain whole for the hogs. If no hogs follow, it is best to grind corn for fattening steers unless corn is exceedingly cheap. Steers may be fed ground ear corn or ground shelled corn.

Less corn is required to produce 100 pounds of gain if the cobs are included in the ration. Much the same results have been obtained from three experiment stations in Iowa, Illinois, and Ohio. Dairy cows almost invariably pay if they are fed ground ear corn rather than shelled or crushed corn. Fattening lambs usually receive shelled corn. Some careful feeders use ground shelled corn.

In future corn-breeding work, it must be remembered that the ultimate destination of most of our corn is feed for livestock, and that most of the corn is fed on the ear or shelled. Beginning in 1915, there was a tendency to breed corn for a horny kernel which is supposed to be associated with higher yield and disease resistance. It must also be remembered that this can be carried too far and that a flinty kernel will make it necessary to grind all corn. About 1940 greater emphasis was placed on producing hybrid corn of medium to soft texture. The kernels with softer starch are in favor with livestock feeders.

The Illinois Experiment Station has carried on some rather extensive research work among farmers in four areas in Illinois, in which the total requirements of grain were calculated from a number of farms feeding corn to cattle. A total of 198

farms were surveyed in groups ranging from 32 to 57. From these figures it is interesting to note the four-year average. Taking the average of the four areas for the four years from 1940 through late 1944, the total corn grain required to pro-

TABLE 22

SUPPLY AND DISPOSITION OF COMMERCIAL CORN IN THE UNITED STATES, 1926–1944 *

		Commercial Supply and Disposition							
Year Beginning October	Production for All Purposes †	Sold from Farms	Imports ‡	Total	Dry-Process Products §	Wet-Process Products ‖	Alcohol and Distilled Spirits ¶	Exports **	Other Uses, Chiefly Feed ††
	million bushels	*million bushels*	*million bushels*	*million bushels*	*million bushels*	*million bushels*	*million bushels*	*million bushels*	*million bushels*
1936	1506	217	104	320	75	67	32	...	146
1937	2643	566	2	568	75	72	18	140	263
1938	2549	575	...	576	76	76	18	34	372
1939	2581	582	1	583	75	83	20	44	361
1940	2462	487	1	489	76	101	26	15	271
1941	2676	544	1	544	83	127	55	20	260
1942	3132	581	...	582	93	128	42	20	260
1943	3034	558	4	562	94	121	11	10	326
1944	3203	730	6	736	95	125	37	17	457

* Compiled by the Commodity Development Division, Northern Regional Research Laboratory, Peoria, Illinois. Stocks at beginning and end of year are disregarded.

† This column is included for purposes of comparison between the total United States production and uses of all corn sold from farms that passes through the central markets for grading. This does not include corn used on farms.

‡ Grain only.

§ Breakfast foods, farm household uses, corn meal, flour, and hominy grits; calendar year following (based on census data).

‖ Starch, sirup, and sugar (Corn Refiners' Statistical Bureau).

¶ Does not include corn products.

** Grain only (Bureau of Foreign and Domestic Commerce).

†† Commercial feed is undoubtedly the principal use.

duce 100 pounds of gain on feeder cattle was 733 pounds. In addition these cattle consumed 60 pounds of protein and mineral feeds, making the concentrate requirement for 100 pounds of gain, 793 pounds. The Iowa Experiment Station found in seventeen years of cattle-feeding experiments that 165 two-year old cattle on feed about 120 days consumed 706 pounds of concentrates, which included grain and protein, to make 100 pounds of gain. Yearling steers feeding 212 days required 764

pounds of grain including concentrates to make 100 pounds of gain. Steer calves were fed an average of 260 days and required 606 pounds of grain including protein concentrates to make 100 pounds of gain.

These figures indicate that cattle are not too efficient in producing beef when fed grain. The change in the quality of beef is sufficient to increase the value per pound of a steer some 20 per cent above his purchase price.

The same Illinois survey obtained information on hog feeding. There were a total of 625 surveys made. The pigs required 449 pounds of grain and 44 pounds of protein and mineral to produce 100 pounds of gain. Some of these pigs were on pasture, some were not, some were fall farrow, and some spring farrow. Many of these pigs had alfalfa hay and others had alfalfa pasture. When we consider that approximately 38 per cent of the Corn Belt corn crop is used for pork production, we can understand the value of the hog-corn ratio tables in Chapter XXVIII. See Table 40.

Value of corn cobs in a fattening ration for steer calves. Gerlaugh, Burroughs, and Kunkle of the Ohio Experiment Station have published a bulletin which states:

> It required 572 pounds of ground shelled corn to make a hundred pounds of gain in the lot fed ground shelled corn. It required 622 pounds of regular corn-and-cob meal in the one lot and it required 646 pounds of the high cob content meal in the third lot.
>
> When we broke these corn-and-cob meals down into ground shelled corn and ground cobs we found that the regular corn-and-cob meal lot required 507 pounds of ground shelled corn and 115 pounds of ground cobs to make a hundred pounds of gain. In the high cob content meal lot, the requirement was 444 pounds of ground shelled corn and 202 pounds of ground cobs. To repeat, 572 pounds of ground shelled corn in one lot, 507 pounds of ground shelled corn and 115 pounds of ground cobs in another lot, and 444 pounds of ground shelled corn and 202 pounds of ground cobs in a third lot.
>
> On the basis of gains, the cobs in the regular corn-and-cob meal were worth 56 per cent of their weight of ground shelled corn, and in

the high cob content meal the cobs were worth 63 per cent of their weight of ground shelled corn.

The cobs in a bushel of ear corn when ground do produce 1 pound of gain on feeding cattle. Cattle feeders who feed ground ear corn are almost unanimous in their opinion that such cattle are easier to "keep on feed." Successful cattle feeders may and do use ear corn, crushed ear corn, ground ear corn, shelled corn, and ground shelled corn.

Comparable values of Corn Belt feeds. The following table gives the comparative values of corn and other feeds based on chemical analyses, when nitrogen-free extract (starch) is valued at 1 cent per pound, fat at 3 cents, and protein at 5 cents per pound.

TABLE 23

Grains	Value per Bushel
Corn, No. 3	$1.00
Oats	0.61
Barley	0.90
Rye	1.08
Wheat	1.18
Soybeans	2.21
Commercial Feeds	**Value per Ton**
Bran	$41.32
Standard middlings (shorts)	44.70
Hominy feed	39.79
Cottonseed meal (39 per cent) *	74.06
Linseed oil meal (old process)	64.12
Corn gluten feed	53.87
Corn oil cake meal	53.90
Molasses feed (10 to 15 per cent fiber)	35.62
Soybean oil meal	74.71
Tankage (60 per cent)	92.34
Molasses (blackstrap)	22.81

* Cottonseed meal is actually worth only about 85 per cent as much as this chemical analysis value. Molasses feed and molasses are probably worth somewhat more than the values given because of a certain palatability which they possess.

Barley, wheat, and rye must be ground if they are to have a feeding value as high in relation to corn as indicated in this table.

No animal can make satisfactory growth on corn alone. With hogs, the bone- and muscle-building material in which corn is lacking may be supplied by small amounts of tankage, oil meal, dairy by-products, pasture, and alfalfa or clover hay. With cattle and sheep, oil meal, cottonseed meal, clover hay, alfalfa hay, or pasture most commonly supply the necessary protein and mineral matter. There is available on the market commercial concentrates ready to feed to livestock to supply protein not furnished by corn grain.

SELLING CORN AS GRAIN

The total corn in Table 22 for dry process, wet process, alcohol, and distilled spirits, plus the exports and other uses, make up the amount of corn that leaves the farm annually. Most of this corn passes through the corn markets at Chicago, Omaha, Peoria, Indianapolis, St. Louis, and Kansas City. Chicago handles more grain than do any of the other cities, but Chicago does not control so large a portion of this grain as formerly. Northwestern Iowa, central Illinois, and eastern Nebraska furnish approximately half the corn that is received at primary markets.

From farm to local elevator. In northwestern Iowa the method of handling corn which is eventually sold at Chicago is as follows: The farmer hauls his shelled corn to the local elevator. The custom charge for shelling corn in the winter of 1946–1947 in Iowa was 2 cents a bushel. It is sometimes slightly more. The man who operates the custom sheller may also furnish the trucks for hauling the corn to market. The hauling charge is based on distance, usually about 3 cents for 5 miles, which is the standard rate established by the Interstate Commerce Commission for custom hauling by truck.

Nearly all elevators are equipped to make moisture tests on the corn they buy, and the corn is bought subject to the grade. This grade is determined by the requirements which appear later in this chapter. During the early season in December and January, the moisture may be high enough so that the corn will be graded No. 4 and even No. 5. The freight and handling charge will be about 13 or 14 cents a bushel to Chicago from northern Iowa. The handling charge may be on a percentage basis or it may be on a bushel basis. Beginning along in April, May, or June, when the corn in cribs on the farm shows less moisture, the corn may sell in Chicago as No. 3 or perhaps No. 2 grade, but the shelling and handling charges per bushel are much the same. The smaller markets within the Corn Belt, like Sioux City, Cedar Rapids, Des Moines, and St. Joseph, now have all the necessary facilities for grading corn so that it may be distributed to the commercial channels without having to go through Chicago.

Types of country elevators. There are three kinds of country elevators: (1) independent, (2) "old line," and (3) farmers' cooperative. The independent elevator is usually owned by a local man in a small town, who operates his own business. In addition to running a grain business, such a man may be a banker, lumber dealer, or feed dealer. The "old line" elevators are quite likely to be owned by large corporations. They buy the corn direct from the farmer much as the independent dealer does and dispose of it at their connections at central markets. The farmers' cooperative elevators either accept the corn from their local members or buy corn from farmers who are not members. This corn goes through the cooperative general office to any other purchaser. This general office does business for a number of local elevators. In Iowa something like 55 per cent of corn sold for cash off the farms originates in farmers' cooperative elevators.

There are two ways in which country elevators may sell grain at Chicago, Omaha, and Kansas City. Country elevators may ship their grain to Chicago or to other large

markets as fast as they are able to fill the cars, or they may ship a little more leisurely and protect themselves against a decline in the market by "hedging" (selling short as many bushels of corn for future delivery as they have bought from the farmers. If the elevator does not take out any price insurance in the form of hedge sales, it will make a speculative profit above expectations if the Chicago market advances before the car gets to it. On the other hand, there may be a speculative loss if the market falls. This speculative risk becomes very great in years of car shortage, which may cause the lapse of several weeks between the time the corn is purchased from the farmer and the time it is sold at Chicago.

When an elevator deals only in cash grain without any hedge insurance, it is necessary to pay $18 to $25 a car (1 to 1.5 cents per bushel) for brokerage and miscellaneous charges. If, however, an elevator takes out hedge insurance by selling "future" corn at the time the purchase is made from the farmers, it is necessary to pay about ¼ cent per bushel in addition for the insurance.

The method of hedging may be illustrated by the following example: An elevator buys corn on February 20, which it expects to ship some time in March. May future corn, which is the nearest future, is quoted at $1.00 and the cash No. 3 corn is 94 cents. The elevator must purchase corn from farmers at 15 cents below the Chicago price for the same grade, and it, therefore, pays 85 cents for 1500 bushels of corn. On the same day it wires a commission company at Chicago to sell 1600 bushels of May corn at $1.00 (the 6-cent difference between the February cash No. 3 corn price and the May future is in part caused by contract future corn being No. 2 and in part by the two- or three-month storage charges). When the corn is finally received in Chicago, on March 10, the price of the May future may be 93 cents and the cash No. 3 corn 87 cents. In that event, the elevator, in buying back its paper contract on March 10, makes a profit of 7 cents a bushel, which enables it to meet the loss on the cash corn. On the

other hand, an advance to $1.08 for May future corn and $1.02 for No. 3 corn will result in a loss of 8 cents a bushel on the paper corn, which counterbalances the gain of 8 cents on the actual corn. Either way, the net result is that the elevator gets for its corn a price about equivalent to what it paid the farmers on February 20.

The theory of hedging is attractive, and the practice is fairly good. Unfortunately, some elevator managers succumb to the temptation to buy and sell paper grain above what is needed for purely hedging purposes. Also, the cash grain and future grain markets do not always maintain the sympathetic relation toward each other which is necessary if hedging is to be perfect price insurance. The Chicago Board of Trade handles grain dealings in Chicago. The Commodity Exchange Commission is a part of the U. S. Department of Agriculture. The commission establishes the amount of deposit that must be made for purely speculative deals in corn and the charge to be made for hedging. The deposit required in speculative dealing has been as high as 50 per cent of the purchase price of the corn and as low as 7 cents a bushel.

The four futures commonly dealt with on the Chicago Board of Trade are May, July, September, and December. Commission firms charge ¼ cent per bushel or $2.50 for 1000 bushels for the sale and purchase. In addition, it is necessary to put up with commission firms from 1 to 1½ per cent for handling hedges, to serve as margin to protect the commission company if the corn goes up before the deal is closed. Hedging can be made really useful by elevator managers, especially when they are unable to ship promptly and when the tendency of the market seems downward. With line elevators, hedging is usually taken care of from a central office.

The Grain Futures Act, which was passed by Congress in 1922, gave the U. S. Department of Agriculture power to designate certain markets as contract markets for trading in futures. Regulations could also be prescribed with the idea of making it possible for the future grain prices to register actual changes

in supply and demand conditions rather than mere speculative raids and corners. The act was designed to make it possible to use the Chicago market for hedging purposes with greater safety than before.

In June 1936, the Commodity Exchange Act was passed. The Grain Futures Act was amended and now comes under this new title. This act contains a number of new provisions from the standpoint of the country shipper who uses the futures market for hedging purposes. One of the most important is the provision which requires commission houses to handle customers' margin money with considerably more care than heretofore. Commission firms are specifically prohibited from commingling such margin money with their own funds; neither can they use any part of the margin money of any one customer to extend credit to any other customer.

MARKET GRADES OF CORN

When grain cars reach the terminal market, they are switched onto grain tracks where they are examined by government grain inspectors. Samples of grain are secured from each car and taken to a grain-grading room where the percentage of moisture is ascertained and the corn is given a definite grade on the basis of the Federal Official Grain Standards as set forth in Grade Requirements on page 271.

The following information was taken from the Extension Service of the U. S. Department of Agriculture, July 1945:

Farmers know they cannot get top prices for shelled corn that is wet, dirty, or damaged. On the market corn is sold by grades No. 2, No. 3, No. 4, No. 5 and by Sample grade. Dry, clean, heavy, sound corn grades high. [See page 321.]

When grading a sample of shelled corn, a trier or probe is used to draw a fair average sample. The sample is looked over carefully for weevils or other insects. If corn is infected with insects injurious to stored grain, the word "weevily" is added to the grade designation. Corn that smells musty or sour or has other objectionable odors is

placed in Sample grade. Corn that is heating is also graded as Sample. A moisture test is necessary to determine the amount of moisture in a sample. A weight per bushel test determines the weight of one bushel by measure (2150.42 cubic inches) of the sample.

Samples should contain about $1\frac{1}{8}$ pints. A sieve with round holes, $\frac{12}{64}$ inch in diameter, is used to remove cracked corn and foreign

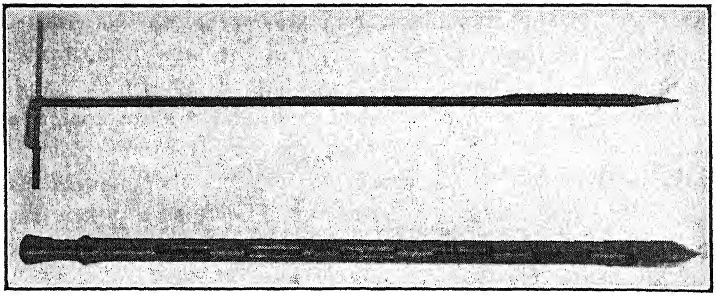

FIG. 48. These two objects are the Iowa ear-corn probe and the shelled-corn probe. The ear-corn probe has a handle at right angles to the main shaft. This handle permits the twisting of the probe from right to left and from left to right while it is inserted into the center of the ear corn crib. The saw teeth shell some corn which drops into the opening in the shaft. When the opening is closed by means of a little lever, the probe is withdrawn, bringing with it a sample of shelled corn from the center of the crib of ear corn. The shelled-corn probe takes the sample of shelled corn at six different points along the shaft. They are closed when the probe is inserted, open when it is in position, and then closed again when it is withdrawn, furnishing samples from six different locations.

material. Any material other than corn that remains on top of the sieve is removed and added to the screenings. The material removed is weighed and the percentage by weight is calculated. See table [page 271] for allowances under "Cracked corn and foreign material."

The damaged kernels from a 250-gram portion of the cleaned corn are separated, weighed and calculated. See table for the percentage of mechanically damaged kernels permitted in the grades. When heat-damaged kernels are present they are weighed separately and the percentage of each computed.

Corn is divided into three classes: Yellow, White, and Mixed. Yellow corn may contain not more than 5 per cent of other colors, and White corn not more than 2 per cent of other colors. Mixed corn is all corn that does not meet the color rules for yellow and white.

Of the tests given above, only the one that fixes the lowest possible grade need be made.

For example, the moisture test is the only one usually necessary for damp corn. For dry corn, another factor, such as damaged kernels, may fix the grade.

Your local grain dealer, who uses the Federal corn grades, can show you how these seven tests are made. See your county agricultural agent, or write to your State agricultural college, for more information about corn. Licensed grain inspectors and Federal grain supervisors of the Office of Marketing Services, U. S. Department of Agriculture, are located in the larger markets, and can give you further advice on grading corn.

GRADE REQUIREMENTS

Grade No.	Minimum Test Weight per Bushel	Moisture	Cracked Corn and Foreign Material	Damaged Kernels Total	Damaged Kernels Heat-Damaged
	pounds	*per cent*	*per cent*	*per cent*	*per cent*
1	54	14.0	2	3	0.1
2	53	15.5	3	5	0.2
3	51	17.5	4	7	0.5
4	48	20.0	5	10	1.0
5	44	23.0	7	15	3.0

Sample — Sample grade shall include Yellow corn, White corn, or Mixed corn that does not come within the requirements of any of the grades from No. 1 to No. 5, inclusive; or which contains stones or cinders or both; or which is musty, or sour, or heating, or hot; or which has any commercially objectionable foreign odor; or which is otherwise of distinctly low quality.

CORN LOAN PROGRAM

In 1933 the U. S. Department of Agriculture developed a plan to loan money to corn producers. The security for these loans was to be the corn in storage on the farms. No loans

were to be made except to men who actually produced the corn. This was a successful effort to distribute the sale of corn over a wider period of time during the year. Furthermore, it was intended to give the producer an opportunity to market his corn at the time he chose during the year and still be able to

TABLE 24

CORN MOISTURE DISCOUNTS ON DES MOINES CASH GRAIN MARKETS, MARCH 19, 1947

1¢ each ½% to 20%; 1½¢ each ½% 20% to 23%

15%	0	$1.00
15½ to 16%	1¢	0.99
16 to 16½%	2¢	0.98
16½ to 17%	3¢	0.97
17 to 17½%	4¢	0.96
17½ to 18%	5¢	0.95
18 to 18½%	6¢	0.94
18½ to 19%	7¢	0.93
19 to 19½%	8¢	0.92
19½ to 20%	9¢	0.91
20 to 20½%	10½¢	0.89½
20½ to 21%	12¢	0.88
21 to 21½%	13½¢	0.86½
21½ to 22%	15¢	0.85
22 to 22½%	16½¢	0.83½
22½ to 23%	18¢	0.82

use the money that was represented by the corn crop. A loan rate per bushel was established the first year. The amount of money loaned per bushel has changed from year to year ever since; it is known as the ceiling price on corn. Typical regulations for corn loans are given here in considerable detail. These regulations were applicable to the 1946 corn crop.

1. *Availability of loans.*

a. Area—loans will be made available in all states where farm storage is feasible.

b. Time—from December 1, 1946, through July 31, 1947, except in Angoumois moth infestation areas where loans will be available only through March 31, 1947.

2. *Lending agencies* need to be approved by the Commodity Credit Corporation.

3. *Eligible producer.* An eligible producer shall be any individual, partnership, association, corporation, or other legal entity producing the commodity in 1946, as landowner, landlord, tenant, or sharecropper.

4. *Eligible commodity.* Eligible corn shall be merchantable ear or shelled field corn produced in 1946, by an eligible producer, in areas where farm storage is feasible, provided:

a. The beneficial interest to such corn is and always has been in the eligible producer; or

b. Such corn was purchased by an eligible producer who will operate a different farm in 1947 from that operated in 1946, and the number of bushels placed under loan is not in excess of the total number of bushels produced by the producer on the farm operated by him in 1946.

5. *Eligible storage.*

a. When stored on farms: Eligible storage shall consist of cribs or bins which, as determined by the county committee, are of such substantial and permanent construction as to afford protection against rodents, other animals, thieves, and weather.

The most important factor to be considered in the safe storage of corn is the crib width. [See Fig. 46.] Cribs having a width greater than the recommended width for the county will not be considered as safe for storage of corn offered for a loan, unless the moisture content of the corn is less than the applicable permissible moisture content by at least 1 per cent for each foot or fraction thereof in excess of the recommended width. In the case of round cribs with center ventilator the distance from the ventilator to the outside wall shall be used as the width, and for round cribs without center ventilator two-thirds of the diameter shall be used as the width. Maximum crib widths for safe storage of corn are listed on a schedule.

b. When stored in warehouses: Not applicable.

6. *Determination of quantity.* A bushel of ear corn shall be 2.5 cubic feet of ear corn testing not more than 15.5 per cent in moisture content. An adjustment in the number of bushels of ear corn will be made for moisture content in excess of 15.5 per cent in accordance with the following schedule:

Moisture Content	Adjustment Factor
per cent	*per cent*
15.6 to 16.5 both inclusive	98
16.6 to 17.5 both inclusive	96
17.6 to 18.5 both inclusive	94
18.6 to 19.5 both inclusive	92
19.6 to 20.5 both inclusive	90
Above 20.5	No loan

A bushel of shelled corn shall be 1.25 cubic feet of shelled corn testing not more than 13.5 per cent in moisture content.

SOFT CORN

Corn is the only crop of tropical origin that is grown successfully on a large scale in the temperate zone. Getting the grain properly mature under northern conditions is, therefore, a special problem. The term "soft corn" is used to designate corn on the ear which has too much water in it to be handled successfully by ordinary methods. Soft corn may come from apparently mature plants which still have too high a percentage of moisture at harvest time. More frequently it is from plants whose growth was stopped by a killing frost before they were completely mature. If immature corn is dried to 17 per cent moisture or less, it is known as "chaffy" corn. Immature and wet corn may be produced in any area in unfavorable seasons. If the planting is delayed in the spring or if the growing season is cold and wet, the corn does not arrive at the usual blossom stage early enough in the growing season to permit the corn to be fully supplied with nutrients from the soil before freezing weather stops all growth.

Soft corn in the field at harvest time may be allowed to remain in the field until it is dry, even if the time required is the following April or May. Soft corn is not usually left in the field that long. There are records of fields of the 1945 crop that were not harvested until late April 1946 and were graded No. 3 on the market. True, the kernels were on the chaffy

order, but there was no mold or insect damage. Another practice in handling soft corn is to turn hogs in the field. This is known as hogging-off corn. The area that may be handled on any farm by this method is largely determined by the number of hogs and by the presence of a hog-tight fence around the corn field. The hogs will continue to eat this corn rather readily even though it is frozen. Occasionally such corn is harvested by turning in cattle. It is necessary to have the cattle on full feed before they are turned in. Any supplementary feed may be supplied in troughs or bunks.

Cribbing soft corn. If wet corn is harvested as late as possible in the fall, the temperatures will likely be low enough in the northern part of the Corn Belt to greatly retard any development of molds in the corn crib. If soft corn is put in the crib, special emphasis needs to be put on ventilation through the middle of the crib. This is necessary if the owner intends to carry the corn over to the next summer.

Soft corn may be salted at the rate of about 1 pound of salt per hundred pounds of soft corn. This salt aids in preventing prompt development of molds. The salt will not prevent all chances of heating or all growth of mold. If the weather is warm after the soft corn has been cribbed, mold will develop even if salt is present. More than 1 pound of salt per hundred pounds of ear corn has not been found satisfactory if the corn is to be consumed by livestock.

Shelling soft corn. Soft corn may be too wet to shell in the early fall or winter. When the temperature is down around zero the corn will be frozen hard, will shell readily, and may be sold through the normal market channels, subject to discount in accordance with its grade. This shelling and selling of soft corn in winter offers an opportunity for a cautious grain producer to market his crop without a serious loss from mold or heating in the crib. Soft corn quite often goes to distilleries. Soft corn may be dried in the crib by artificial ventilation and artificial heat. This practice is not yet extensively used. Each year an increasing number of corn growers are

artificially drying corn in cribs. When feeding soft corn, it may be best to feed the corn to cattle and hogs exclusively. The mold that may be present on soft corn is dangerous for sheep and horses.

Feeding value of soft corn. Corn that is mature and still wet has a feeding value per pound of dry matter quite comparable to the pound of dry matter in corn of 15 per cent moisture. Soft corn that is immature and wet is not considered highly satisfactory for feeding purposes. The dry matter in a pound of immature soft corn is slightly less valuable as feeding corn than a similar amount of dry matter in mature corn.

TABLE 25

SOFT-EAR CORN COMPARED WITH HARD-EAR CORN FOR FATTENING YEARLING STEERS AND STEER CALVES

(All steers and calves were fed alfalfa hay and mineral.)

Items	Yearlings (Fed 149 Days)		Calves (Fed 195 Days)	
	Fed Soft Corn	Fed Hard Corn	Fed Soft Corn	Fed Hard Corn
	pounds	*pounds*	*pounds*	*pounds*
Initial weight per steer	723.5	725.4	446.8	448.5
Final weight per steer	1075.2	1050.2	882.1	855.5
Daily gain per steer	2.36	2.18	2.23	2.09
Feed for 100 pounds gain				
Corn	1073.1	887.5	921.7	736.5
Oats	11.8	12.9	9.5	10.2
Soybean meal	4.5	4.8	2.5	2.6
Alfalfa hay	249.9	270.6	218.9	232.1
Mineral	3.6	5.0	2.9	4.1
Pork gains per steer *	49.4	47.6	48.6	48.2
Market shrink per steer	44.2	51.8	35.8	33.1
Average dressing	58.5%	58.3%	57.6%	57.3%
Average carcass grade	Top good	Top good	Low choice	Low choice
Selling price per cwt	$15.00	$15.00	$14.00	$14.00

* The value of the tankage, 3.4 pounds for the yearlings and 7.9 pounds for the calves, should be deducted from the value of the pork gains per steer.

Table 25 is taken from an investigation of the South Dakota State College. In addition to the calves and yearling steers listed in the table, hogs and lambs were fed during the same experiment, comparing the nutritive value of soft corn against hard corn. The yearling steers were the most efficient of the four; the calves were almost as efficient. The hogs were slightly less efficient than the lambs. Pound for pound, moisture-free dry matter of soft corn is slightly less valuable in the feed ration than is moisture-free dry matter in No. 3 corn. Both the cattle and calves ate slightly more dry matter during the feeding period when they were eating soft corn than when they were eating No. 3 corn.

Soft corn fodder and silage. Soft corn may be harvested with the corn binder, shocked in the field, and allowed to dry. It may be fed to the cattle as fodder. Such fodder may be shredded and the corn removed in the shredding process. The shredded stover is used as roughage or bedding, and the corn removed by the shredder is cribbed. If the corn is still too wet for cribbing without ventilators at the time the fodder is shredded, such corn will need the same attention as any other corn being cribbed with high moisture content. Soft corn may be put in the silo with a field chopper or corn binder and silage cutter. Such corn makes satisfactory silage with little waste in the food value of the crop. It may be possible to harvest a considerable portion of corn from one farm for silage. In the cash grain area of northwest Iowa and southwest Minnesota, silos are not available. Corn producers in this area are not all experienced livestock men; hence their opportunity of using silage is not so great as in some other locations. Soft corn years in the Corn Belt or parts of the Corn Belt include 1902, 1916, 1917, 1924, 1945, and 1946.

Soft corn that is produced in eastern North Dakota and central South Dakota is often left in the field to be harvested with cattle or sheep and lambs. North Dakota harvests about one-half its corn crop by pasturing with hogs, cattle, or sheep. South Dakota harvests about as many acres by this method

as does North Dakota. Nebraska is not far behind in total acreage thus harvested. Montana harvests about 70 per cent of its corn crop (42,000 acres) for livestock pasture. In the Dakotas and Montana, much of the flint corn is harvested with livestock. (See Chapter II, Table 3.)

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CHAPTER XXII

COST OF CORN PRODUCTION

In recent years considerable interest has been shown in production costs of corn. The usual method of figuring the cost of producing a crop of corn, or any other crop for that matter, is to determine the quantities of the physical factors of production, such as hours of labor and power and quantities of seed, fertilizer, and twine, and to convert these physical cost elements to a money equivalent by multiplying the quantities by price or value figures. To these costs are added such items as the cost of operating machinery, rental of land and buildings, and a computed overhead cost for labor, power, and materials in the general operation and maintenance of the farm.

Calculated in this manner, production costs include charges for the labor of the farmer and members of his family at current wages, and a charge for his land on a cash-rental basis or in the form of interest on the value of the real estate. If the price received for the product just equals its cost, the product has returned to the farmer enough to cover cash outlay and whatever allowances were included as costs for his labor and use of capital. Consequently, in periods of low farm wages, low land values, and low prices, low production costs are, in general, accompanied by low returns for the farmer's labor and return to capital. It naturally follows that cost figures of this kind do not represent what the farmer should get for his product in order to maintain any specific standard of living, but more nearly what it would have cost him to hire others to do his work and to rent land for farming.

Over a period of years, any real consideration of the cost problem by the farmer involves an attempt fully to develop his resources. High costs, year after year, mean that his resources as a whole are not being utilized to best advantage; low costs mean that he is developing his factors of production, or his resources, in an efficient and economical manner. By studying costs the individual farmer may best determine his proper farm organization and may best decide not only what and how much of each crop to produce, but also the methods of production. Farmers in widely separated regions of the United States can determine the various proportions of their land and other resources to be devoted to the production of each crop and class of livestock.

Considerations involved. In general, it is not difficult to determine for an individual farm, or an average of a group of farms, the physical quantities of production for a specific crop at a given time. Many factors are involved, however, in evaluating the various cost elements. Purchased goods are, of course, charged to the enterprise at actual cost, but it is rather difficult to establish the values of such production factors as the operator's own labor, charges for buildings and machinery, barnyard manure, and horse work.

A rough approximation of a reasonable charge for some items is the best that can be done. In some instances the minor importance of the cost item does not warrant any great amount of time and effort in arriving at a cost rate.

The cost of power to produce corn may be figured just as the cost per hour for operating the tractor is figured. Total hours per year should include repairs, interest on investment, housing, and depreciation. Where horses are employed extensively, the expense may be determined by charging the horses for feed eaten and for labor and depreciation, and charging the corn crop with that portion of the labor done by horses.

Another consideration in figuring production costs has to do with joint costs. The farmer who produces an acre of corn

at a given cost obtains from that acre a given quantity of grain and a given quantity of stover or stalk pasture. These different products have different values. To determine the cost of producing the grain, the usual method is to consider the stover or stalk pasture as a by-product and to subtract its value from the gross cost per acre. The corn stover left in the field by a mechanical picker does not have a great deal of value. There may be some value to the corn left in the field. It may be considered part of the return from growing corn, provided this corn could be economically utilized by livestock. Usually the gross cost is distributed to each product on the basis of the value of each. These are only a few of the problems involved in evaluating joint costs.

As indicated previously, not all elements of farm costs are cash or out-of-pocket costs. In calculating the cost of producing corn, the farmer may be allowed for his own labor any wage that seems reasonable; but, if the price is not sufficiently high to cover all costs, the farmer has not received the full pay allowed in making the cost calculations. It naturally follows that out-of-pocket costs, or current cash costs, are usually considerably less than the total cost calculated by any generally accepted method. A distinction between total costs and out-of-pocket costs is necessary for an intelligent understanding of the reasons why a farmer may continue to produce for many years when total costs, as generally computed, are higher than the price he receives for his product. The corn grower may draw on the reserve of the fertility of his farm and sell the corn crop, each crop showing a big profit, unless he charges against his crop a decline in the fertility of the cropping acres.

The problem of economically utilizing the farmer's resources, which are his cost elements, involves a consideration of variable and fixed costs. Variable costs are those that are dependent on volume of production; fixed costs are those that do not change with volume of production. The farmer who pays to have his corn crop gathered at 7 cents per bushel pays

less for harvesting an acre of corn that produces 50 bushels per acre than an acre that produces 75 bushels. On the other hand if he hires a man with a corn picker at $4.00 per acre, the cost per bushel harvested is less with the higher yield. His efficiency goes up with the increased yield.

Labor and power requirements in the Corn Belt. Labor and power requirements for growing and harvesting an acre of corn in the United States vary greatly, depending principally on the utilization of the crop, size of machinery, size and shape of fields, and yield of corn as affected by soil and climatic conditions.

In the main producing areas of the Corn Belt, when corn is harvested from the standing stalk, labor and power requirements vary somewhat, depending on the size of machinery and power units.

Attention here is called to long-time records accumulated since 1913 by the University of Illinois (see Table 26). A careful study of these figures will show that in the beginning not many acres were included in the studies. In the early days the investigator traveled from farm to farm on horseback or on foot. Great effort was made to return to the farm about every week or ten days. With the cooperation of the farmer it was possible to estimate the labor and expense that were necessary for the preceding week to accomplish what had to be done for the corn or corn crop. It is also well to bear in mind that these counties are not adjacent to each other. This table is a fair estimate of what it cost to produce corn in Illinois year by year since 1913.

With the exception of 1914, 1934, and 1936, there was a gradual increase in yield in bushels per acre. These three years, if studied separately, indicate that the cost of producing a bushel of corn for each particular year was distinctly increased. The smaller average yield was the result of weather conditions and not poor farm management. These three years illustrate definitely that a part of the cost of growing corn is not controlled by the farm operator or the location of his farm.

TABLE 26

Cost of Corn Production in Two Illinois Counties, 1913–1945, Inclusive *

Year	Total Acres Studied	Yield per Acre	Man Labor per Acre	Horse Labor per Acre	Tractor Use per Acre	Man Labor per Bushel	Total Acre Cost	Total Acre Income	Net Profit or Loss per Acre	Net Cost per Bushel	Price per Bushel
		bushels	*hours*	*hours*	*hours*	*hours*	*dollars*	*dollars*	*dollars*	*dollars*	*dollars*
1913	335	34.6	18.6	42.2	...	0.54	18.49	20.79	2.30	0.52	0.60
1914	408	22.2	16.3	37.5	...	.73	19.45	13.63	−5.82	.85	0.59
1915	505	48.5	20.5	51.2	...	.42	19.96	25.93	5.97	.40	0.52
1916	512	36.0	19.0	43.5	...	.53	19.47	23.50	4.03	.52	0.64
1917	716	43.9	18.3	41.8	0.3	.42	21.33	41.81	20.48	.47	0.94
1918	544	34.5	19.2	43.9	0.1	.56	22.76	39.27	16.51	.64	1.12
1919	417	49.2	19.1	46.3	0.3	.39	25.47	64.41	38.94	.49	1.28
1920	656	50.9	14.2	33.4	0.5	.28	31.06	33.46	2.40	.55	0.60
1921	997	49.5	15.0	33.4	0.6	.30	24.81	16.82	−7.99	.48	0.32
1922	1187	48.0	13.9	33.5	0.9	.29	25.12	29.18	4.06	.45	0.52
1923	1503	47.7	14.4	36.7	0.4	.30	29.85	30.11	0.26	.61	0.61
1924	1587	42.8	12.8	28.0	0.8	.30	30.08	42.88	12.80	.68	0.98
1925	1696	51.7	13.9	34.1	0.9	.26	30.47	28.53	−1.94	.57	0.53
1926	1560	53.8	14.1	31.2	1.0	.26	28.65	27.44	−1.21	.52	0.50
1927	1513	44.0	12.7	30.6	1.2	.29	26.74	30.65	3.91	.60	0.69
1928	1213	49.5	13.6	31.1	1.0	.27	26.66	32.77	6.11	.53	0.65
1929	2246	50.4	12.1	25.9	1.6	.24	25.73	34.79	9.06	.50	0.68
1930	1819	39.5	12.8	25.1	1.7	.32	24.38	24.47	0.09	.60	0.60
1931	1661	49.6	12.2	26.6	1.7	.25	21.73	12.82	−8.91	.43	0.25
1932	2743	57.4	11.6	25.2	1.7	.20	16.29	6.47	−9.82	.28	0.11
1933	3696	36.3	10.2	20.4	2.0	.28	15.48	12.90	−2.58	.41	0.34
1934	1113	26.5	10.7	23.3	2.0	.40	16.27	19.47	3.20	.60	0.72
1935	2092	58.1	11.3	20.6	2.5	.19	17.96	26.65	8.69	.30	0.45
1936	1012	31.6	8.7	12.2	2.9	.27	17.48	30.77	13.29	.53	0.96
1937	3091	60.8	8.9	9.2	3.6	.15	18.19	31.13	12.94	.29	0.50
1938	2279	61.2	8.1	6.5	4.2	.13	17.53	24.97	7.44	.28	0.39
1939	2340	62.5	8.1	6.5	4.2	.13	18.38	28.60	10.22	.29	0.45
1940	2415	55.6	7.4	4.3	4.6	.13	18.97	29.88	10.91	.34	0.53
1941	2175	72.4	7.7	3.8	4.9	.11	19.67	48.76	29.09	.27	0.55
1942	2012	71.4	7.7	2.9	5.3	.11	21.31	51.78	30.47	.29	0.70
1943	2217	66.5	6.6	1.6	4.9	.10	21.24	65.20	44.65	.31	0.98
1944	2238	56.4	6.4	0.9	4.7	.11	22.15	57.03	34.38	.38	1.00
1945	2039	60.6	6.7	1.0	5.0	.11	24.72	65.38	40.66	.40	1.07

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R. H. Wilcox, W. C. Kayser, and H. C. M. Case, *Complete Costs and Farm Business Analysis on 31 Farms*, Revised, Grain-Farming Section, AE-1672, August 1941.

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It is definitely influenced by unusual weather conditions. In the years 1914, 1934, and 1936, there was a decided deficiency in moisture during the corn-growing season.

It should be noted that beginning about 1937 there was a rather gradual and quite regular increase in yield per acre. Part of this must be attributed to better management and part of it to the introduction of hybrid corn. The column showing hours of man labor per acre has shown a gradual decrease from 18.6 hours in 1913 to 6.7 hours in 1945. The same is true for hours of horse labor which decreased from 30.6 hours in 1913 to 1 hour in 1945. The column of figures showing the use of tractor begins with no hours and shows a rather gradual increase; in 1945, the tractor was operated 5 hours per acre. The hours of man labor, of horse labor, and of tractor labor per acre may be observed together to illustrate that, with the increased adoption of the tractor, the hours required by a farmer for growing an acre of corn have been reduced about 65 per cent. Similarly the hours of man labor required to grow a bushel of corn may be followed from 1913 to 1945, inclusive. In the column showing total cost per acre are the charges for the land, taxes, and other minor items which are not designated separately. It will be noted that the total income per acre is affected more by fluctuations in the price of corn than by the yield per acre. The dollars and cents income from an acre of corn is controlled in part by business cycles. This simply means that the man who produces corn either works for nothing, or less than nothing, or takes his income out of the fertility of his soil during low price years.

In no sense are these figures fully applicable to all areas of corn grown in the United States. They are fairly representative of Illinois, which is in the central part of the great Corn Belt. Possibly the men who cooperated with the Illinois Extension Service were a little more conscious of expenses and income than some of their neighbors, and these figures may be a little more favorable to the farmer than would be similar figures taken on a greatly increased number of farms.

Cost of production outside the Corn Belt. In the semi-arid sections, such as western Nebraska and Kansas, where the fields are large and level, the minimum amount of seed bed preparation is involved. Fewer man-hours and far fewer tractor hours are used. The yield per acre is less, however, which may mean that the cost of growing corn in Nebraska is not too different from the cost of growing corn in Illinois. In the south where the fields are small and irregular in shape and where a mule or two mules are used in producing corn, the total labor for growing a bushel of corn increases in proportion to the amount of work done per hour in the field by a man and his team and to a much lower yield per acre. In the New England states, fields are small and irregular in shape, and the cost of producing an average acre of corn is somewhat higher than it is in the Corn Belt. On the larger farms in both the south and northeastern states, tractors and power machinery produce satisfactory results in efforts to reduce the amount of labor required to produce and harvest an acre of corn. As a counterbalance, the eastern and southern states import grain and hence can demand a higher price per bushel of corn than Corn Belt states. This difference in price is about equivalent to the cost of shipping corn from the Corn Belt to the eastern or southern corn-importing states.

Reducing costs. On farms where good practices for growing corn and a well-balanced rotation for maintaining the productivity of the soil have been adopted, there is no easy way to reduce materially the cost of producing a bushel of corn. Cost studies invariably show that farms with high yields per acre produce corn at a lower cost per bushel than do farms with low yields. The principal methods for increasing yields and thereby reducing the cost of producing a bushel of corn are: (1) the use of better seed, (2) the adoption of a cropping system to maintain or increase the productivity of the land, and (3) the effective use of farm manure and commercial fertilizer.

CHAPTER XXIII

COMPETING CORN-GROWING REGIONS

The outstanding corn-growing areas of the world are characterized by a mean temperature of 56 to 70° at planting time, a mean temperature of 67° to 81° at tasseling time, a rainfall of at least 5 inches for the fifty-day period centering around tasseling time, and soil moderately rich and fairly easy to cultivate. In the best corn-producing sections of Iowa and Illinois, the mean temperature at planting time is about 61° and at tasseling time about 75°; the rainfall averages about 8 inches during the fifty days centering around tasseling time; and the soil is unusually rich and easily cultivated. There are very few large bodies of land in the world that possess the same combination of factors so favorable to corn as the Corn Belt. Some of the other corn-growing sections are described in this chapter.

THE COTTON STATES

More land is planted to corn in the cotton states than in any other section outside the Corn Belt. Ordinarily, about 35,000,000 acres are planted in these states, compared with about 45,000,000 acres in the Corn Belt. Because of poor soil and a much lower percentage of desirable hybrids, however, the yield averages less than 20 bushels per acre, and the total output of corn in the Cotton Belt is less than half as much as is produced in the Corn Belt. Most of the corn raised in the south is consumed at home. Practically none of it reaches such primary markets as Kansas City, St. Louis, and Chicago.

From one-fourth to one-third of the improved land of the cotton states is put into corn. Cotton has first place in the eyes of the Southern farmers, but corn is a close second. (See Table 3.) In such cotton states as South Carolina, Georgia, Mississippi, and Louisiana, the corn is generally planted during March or early April, but it may be planted as late as June or even July. Plowing is quite generally done with a middlebuster, which is a double moldboard plow substantially the same as a lister, but with no planting attachment. In some sections, especially the western part of the Cotton Belt, the corn is listed in the same way as in Nebraska and Kansas. In poorly drained districts it is planted on top of ridges thrown up by the middlebuster. Listing seems to be growing in favor except in sections where the rainfall is heavy and drainage is poor.

One-horse planters are still used in the south. The two-row planter is being used in increasing numbers. It is used on bigger fields where the ground is more satisfactory for cultivation. Tractors and the mechanical corn equipment that goes with them are appearing on larger farms where corn is grown extensively.

The rate of planting in the south is usually only about one-half as thick as in the north, except on rich bottom lands. On exceptionally poor soil, the rows may be spaced 6 feet apart and the kernels 2 feet apart in the row.

So-called commercial fertilizers, which include nitrogen, potassium, and phosphate, are used extensively in the south. The proportion of each depends on the land where it is to be used and the supply.

The southern corn rootworm is a serious pest in the south and often severely damages corn planted in March and early April. Especially is this true in cold, wet seasons. Corn planted in May ordinarily is not bothered. On well-drained land, where the rootworm usually causes little trouble, it seems to be best to plant in March or early April.

Throughout the cotton states, "prolific" varieties which average nearly two ears to the stalk and often as many as three, are more popular than the single-ear varieties which are almost universally grown in the Corn Belt. The ears of these prolific varieties are only about three-fourths as large as the ears of the single-ear corn, but under southern conditions the average prolific plant yields about 15 per cent more than the average plant of the single-ear type. The typical ear of prolific corn carries twelve or fourteen rows and the kernels are rather flinty with a very smooth dent. The husks of well-bred southern varieties fit tightly to the corn and carry out well past the tip, this husk protection being valued in the south because of the protection against severe damage from insects and birds.

The southern experiment stations are developing hybrids that are suitable for southern states. There is a greater variety of conditions in some of the southern states than in any of the Corn Belt states. The problem of producing hybrids for different conditions within one southern state is therefore more difficult. At the present time much southern corn is white, though several southern experiment stations have taken the lead in converting well-established southern varieties from white to yellow. White corn so far outyields yellow corn in production per acre.

Climatic conditions in the cotton states are quite favorable to corn, although the weather is frequently too dry at tasseling time for best results. The rainfall is usually sufficient to produce an abundant crop, and the cotton states would undoubtedly be another Corn Belt if the soils were only richer. As it is, nearly all the records of corn yielding over 200 bushels per acre have come from the south, such results being obtained by planting corn thickly on heavily fertilized land.

The more progressive farmers in the south are practicing soil conservation, in its truest sense. They are growing legumes like vetch and lespedeza, using more livestock, growing cultivated crops on the contour, and using higher yielding varieties

of corn, including some hybrids. These same progressive farmers are boosting the yield of cotton per acre and will probably be able to produce an equal number of bales of cotton on less than the historical 33,000,000 acres now used. This is in line with the better practices of soil conservation. With a reduced acreage of both corn and cotton, the yield of corn should go up substantially as progressive ideas of conservation increase in popularity and as more high-yielding southern hybrid corn adapted to the south is planted.

ARGENTINA

The Argentine Corn Belt is located about 600 miles nearer the equator than the American Corn Belt. It is a great treeless plain, farmed by tenants or peons. At planting time in November (some corn is planted as early as late September and some as late as December), the temperature is usually about 5 degrees higher than in the Corn Belt during May. At tasseling time in January, the temperature is about the same as in the Corn Belt of the United States. The rainfall during the fifty days centering around tasseling time averages about the same as in our Corn Belt, but there is a little greater danger of really severe drought. The area around the lower part of the Parana River enjoys some 8 inches of rainfall during the summer growing season. This extends east and north of the river for some 150 miles. Argentina grows about 6,000,000 acres of corn annually.

The machinery used for working this soil is quite similar to that used in the major portion of the United States Corn Belt, namely, the plow, harrow, disk, and two-row corn planter. Some corn planters have an attachment called the furrow opener. The corn is planted at about the same rate as it is in the Corn Belt, three or four kernels to the hill. Some of this corn is drilled and some is checked. The planted rows are closer together than is the practice in the United States.

Most of the corn planted in Argentina is of the flint type. There is now quite a demand for hybrid dent corn similar to that grown in the great Corn Belt of the United States. This

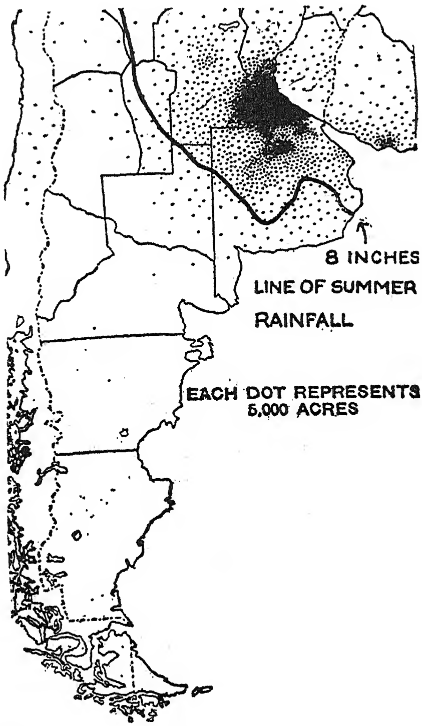

FIG. 49. Argentine corn production is centered in northern Buenos Aires, southwestern Entre Rios, southern Santa Fe, and southeastern Cordoba. Very little corn is grown southwest of the 8-inch line of summer rainfall. Rosario, the Chicago of Argentina, on the River Plata, is a port for ocean-going vessels and is located in the center of densest corn production. (Courtesy U. S. Department of Agriculture.)

demand for dent corn has been stimulated by an increase in the practice of feeding corn to hogs in Argentina.

Most of the land used for growing corn is owned by large landowners. It is share-cropped by the tenants under leases

similar to our crop-share leases in the Cotton Belt. The area per tenant is from 100 acres up, depending upon the ability of the tenant to satisfy the landlord that he is capable of operating on a large scale. The corn is picked by hand and sacked. Each workman has his identification on his sacks. Several workmen gather corn in the same field, and the sacks are gathered up at intervals and taken to the corn crib. Each man is paid according to the number of pounds of corn he has gathered for the day.

The corn crib is usually circular, around a pole set in the ground. The pole has a pulley attached to it. In some cribs the sacks are pulled up by means of a rope and the corn is dropped from the top onto the pile. No snow fences, such as we have, are used for building temporary corn cribs. Many of the circular corn cribs are made of cornstalks standing vertically and then wired around the outside. Corn is shelled directly from these cribs and is taken to the railroad for export. There has been a shift toward hauling corn by truck, but much of it is still hauled by horses from the crib to the railroad.

Perhaps one of the greatest dangers to the corn crop in Argentina is what an Iowa farmer would call a giant grasshopper. The Spanish name is langosta. This grasshopper ranges in length from 1½ to 3 inches. It arrives in great numbers and can be very destructive to all growing crops.

The weeds are somewhat similar to those of the United States Corn Belt: perennials and annuals, vines and grasses, and broad-leaf weeds. Cultivation problems are similar to those of the United States Corn Belt.

The great difference between our midwestern Corn Belt and the Argentina Corn Belt is that in Argentina much corn is raised for cash export crop and not for feed. Flint corn is usually more satisfactory for export than dent corn; hence the demand still continues for flint corn. Livestock does not consume a very great amount of the South American corn crop.

THE DANUBE BASIN

In the Balkan States, Rumania, Hungary, and Yugoslavia, is located the European Corn Belt. The total acreage was 20,000,000 acres before 1941, or about as much land as is put in corn in Iowa and Illinois combined. The average yield is about 20 bushels per acre; in occasional years of failure, the yield is only 10 bushels. The summer temperature averages about 3 degrees less than in central Iowa and Illinois. The annual rainfall is about 20 inches, or about the same as in western Nebraska.

Drought, insects, floods, and hail often cause severe damage. Corn was customarily grown in rotation with wheat, moderately early flint varieties being preferred so that they could be harvested in time to seed winter wheat. The flints are somewhat similar to the Argentina flints. In large sections of the Balkans the farmers broadcast the corn in April and plow it under. When the corn and weeds are about 3 inches high, the farmers go through with a large hand hoe, cut out the weeds and surplus corn, and hill up the earth around each plant. Very few corn planters are used, even on the larger estates where scientific methods of growing wheat are general. Where the land was plowed before planting, the customary method of planting is to drop by hand into holes made with a pointed stick.

The corn is usually harvested by cutting the stalks off with a hoe. It is husked and stored in a crib made of woven saplings and thatched with straw.

There are no accurate reports available on the Balkans and southwestern Russia since World War II. Hybrid corn seed has been supplied in large quantities by the United States.

In Hungary, the methods are somewhat better, but on the whole the Danube corn is produced by peasants who know very little about modern methods of corn growing. Much of the corn grown is used for human consumption.

LATIN AMERICA

Throughout most of Latin America corn is very commonly grown, often in small fields on steep hillsides. The bulk of the crop is consumed locally. The primitive practice of clearing and burning a slope and then planting it to corn was not so destructive as may appear at first sight, since the half-burned logs checked erosion. The practice as a whole was really a rotation system including rapid-growing forest trees and shrubs. In the highlands of South America corn's main use is as a vegetable and for the production of fermented beverages, but in Central America it becomes an important grain crop as in Mexico and the United States. Until recently most of the crop in Latin America has been in primitive hands, but various governments are keenly alive to the possibilities of its improvement. Much of the corn in Latin America is highly variable and many of the types grown there are almost completely unknown in the United States. They constitute a great reservoir of variability, of great potential importance in the development of better varieties for the United States Corn Belt. The government of Brazil has a program financed in part by the Rockefeller Foundation for the breeding and introduction of hybrid corn. This program is based very largely on the development of new inbreds and the planting of inbreds now available in South America.

MEXICO

Since prehistoric times a large percentage of the crop land in Mexico has been put into corn every year. Until 1912 Mexico's corn acreage was exceeded only by the United States. More than in any other country of the world, the life of the common people is dependent on corn. The great bulk of the crop is consumed directly as human food, in the form of tortillas, tamales, and other distinctive maize foods. Much

of the corn grown in Mexico is consumed in the community where it is grown. The "Bajio" (literally the low place) in Guanajuato and adjacent states is one of the corn belts of Mexico and ships to other parts of the country. Over much of Mexico, the crop is divided into the spring plantings in irrigated ground, and the bulk of the crop is planted in early summer when the rains begin. About 8,000,000 acres are planted annually. About two hundred hours of man labor are required to grow an acre of corn in Mexico. The average yield is 10 to 12 bushels per acre.

The Rockefeller Foundation in cooperation with the Mexican government established a corn improvement project in 1942. Seed for commercial planting was produced in small amounts by the spring of 1947.

WESTERN EUROPE

Italy with 4,000,000 acres, Spain with 1,500,000 acres, and southern France with 1,000,000 acres are the chief corn-growing countries of western Europe. Orange-yellow flints are in greatest favor. Much of the Italian corn is grown under irrigation. Italy's "Corn Belt" is in the Po valley. The crop is used chiefly as human food. Polenta, a nourishing corn meal mush, is widely used in northern Italy, both by country people and in such manufacturing centers as Milan, where it is sold in quantity at special shops. All western Europe put together produces less than half as much corn as Iowa. Italy, the leading corn country of western Europe, imports several million bushels annually.

ASIA AND AFRICA

A careful study of world corn production will show that one of the outstanding areas is the Orient. However, this corn is practically all consumed at home; it does not figure in world trade, and accurate information about it is difficult to obtain.

Corn is one of the important human food crops in South China, Indo-China, Burma, Siam, India, parts of the Dutch East Indies, and the southern Philippines. From Indo-China to Burma to Assam there is a considerable area in which the roasting of green corn on the cob is a common practice among the hill tribes. Corn in Asia is infected with a serious mildew disease which has not yet reached the United States.

Egypt grows about 60,000,000 bushels annually on her fertile irrigated Nile soil, but none of it leaves the country.

The Negro tribes of interior Africa have grown considerable corn for home consumption for several centuries. There is no prospect, however, that any part of Africa, aside from southeastern South Africa, will ever produce much corn for export.

In the southeastern part of South Africa is a large section of land about a mile above sea level where the season is long and the summer rainfall is just right for corn. The temperature is ideal except that during the middle of the summer it averages about 68°, or about 4 degrees too low. The chief drawback is a rather poor soil. Nevertheless, wonderful progress in corn growing was made after 1900, and there is a possibility that South Africa may rank eventually with Argentina and the Danube basin in providing western Europe with corn. The favorite South African variety is Hickory King, a large-seeded, late-maturing, twelve-row dent, which is also popular on the poorer soils of the northern edge of the Cotton Belt. Another favorite sort is a variety developed from Champion White Pearl.

Modern corn-growing methods are employed in South Africa, and the English and the Boers are continually at work on the problem of increasing South African corn production. The South Africans seem to have their eyes fixed on the export market. The export trade has been built up on the large, flat white kernels characteristic of such varieties as Hickory King. Programs of corn breeding are beginning to develop good hybrid corn for South Africa.

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CHAPTER XXIV

ECONOMIC FACTORS AFFECTING CORN PRICES

The principal factor causing changes in the season-to-season price of corn is change in the size of the corn crop. The changing level of corn prices, as of other farm products, is also materially affected by changes in the general price level, and these changes in the general price level are associated with changes in consumer incomes. In years of inflation, as during the periods of the two world wars, the general price level was high and the price of corn was high. That is, the price was high compared with non-war years when the supply was not greatly different. In years of depression, as during the great depressions of the 1890's and 1930's, corn prices were very low compared with prices for similar supplies in non-depression years.

If the average farm price of corn for a season, that is, the average for the months from October to the following September, is charted with the size of the corn crop harvested during that year, the inverse relationship between the size of the crop and the seasonal average price is apparent (Fig. 50). The years in which this relationship is not found are mostly years when there was a sharp change in the general price level, either up as in the war periods of 1915–1918 and 1942–1945, or down as in 1929 and 1930.

This inverse relationship between the price of corn and the size of the crop is especially in evidence when there is a marked change in the size of the crop in consecutive years. Such periods occur when adverse weather conditions cut production sharply in one year, followed by a fairly good crop the next year, as in 1923–24–25, and 1933–34–35–36–37. But

even in such periods the effect of size of crop on prices may be either magnified or reduced or actually obscured by a rapid change in the general price level.

The tendency for the level of corn prices to be affected by changes in the general price level is shown by Fig. 51. In

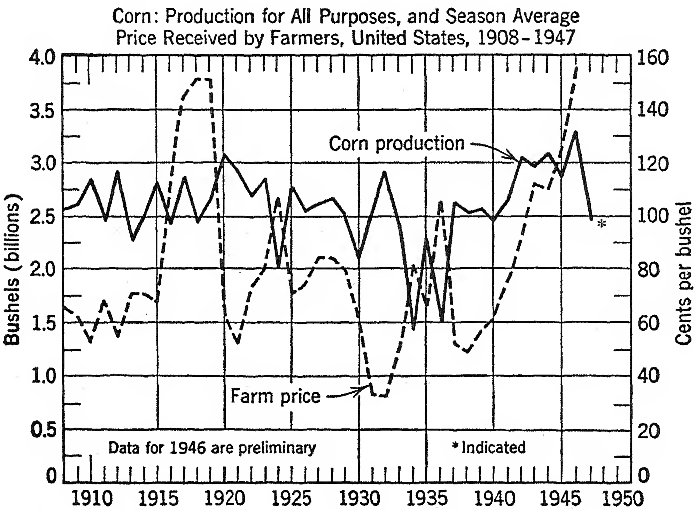

FIG. 50. The inverse movements of corn prices and of corn production are shown clearly by this chart. Although this relationship is most marked in years when there is a sharp change in the size of the corn crop, it is also in evidence in years when the change is relatively small.

years when the general price level was advancing, as from 1900 to 1910, the level of corn prices advanced, but the year-to-year changes in price were due mostly to the year-to-year changes in the size of the crop. In periods of rapid rise in the price level, the price of corn usually advances relatively more. In years of rapid decline of the price level, corn prices go down relatively more.

Although the size of the crop or the supply of corn is the principal cause of change in the seasonal average price, corn prices, like those of all other commodities, are also affected by

changes in demand. To a considerable extent changes in demand are reflected in changes in the general price level, but

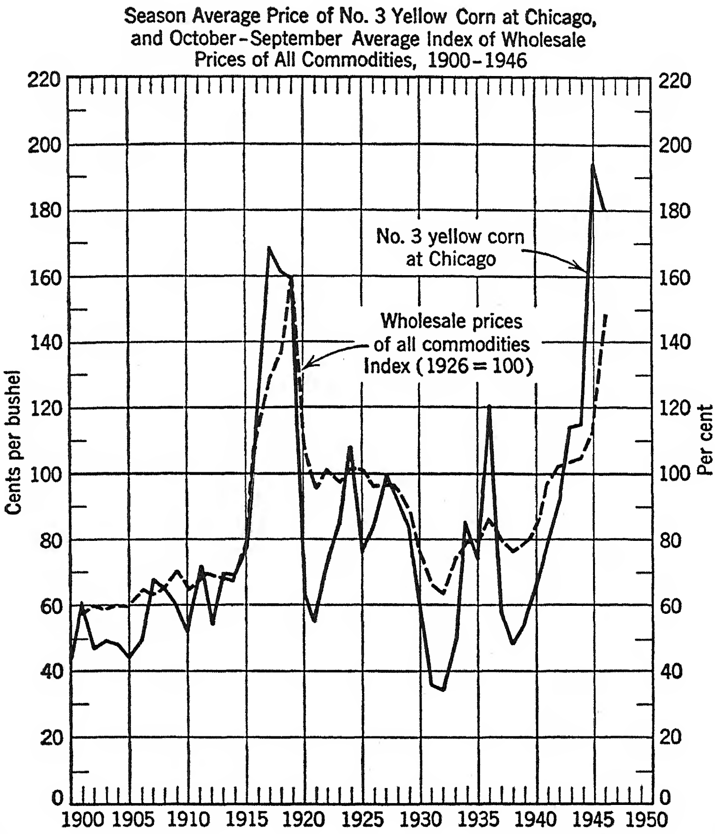

FIG. 51. The seasonal average price of corn is also affected by changes in the general price level. In years when there is a sharp change in this level, this factor tends to obscure the influence of change in supplies.

there are also certain special demands for corn that tend to affect the price. As will be shown in Chapter XXV, there is a very close relationship between the total retail value of hog products and changes in incomes of consumers. This follows

because pork and lard are products for human consumption; they are consumed as they are produced. This is not true with corn. Only a very small proportion of corn produced is processed directly into products for human consumption. Such products as corn meal, cornstarch, distilled corn products, corn sirup, and corn sugar absorb only a small percentage of corn produced. For the five years 1935–1939, this percentage was

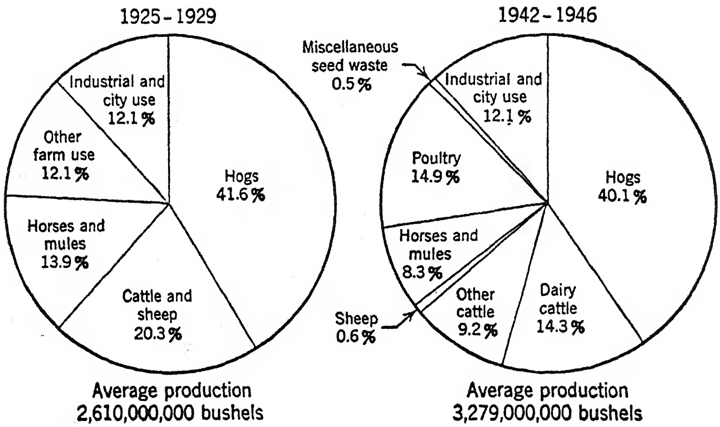

FIG. 52. The uses of corn.

less than 8 per cent of the total corn crop. The greater part of the production is used for feed for livestock and poultry. In earlier years a very considerable proportion of the corn crop was not intended either directly or indirectly for the production of human food. It was, and still is to a smaller degree, fed to work animals for production of power on farms and in towns and cities. This utilization has dropped off markedly in the last twenty years, resulting in a larger proportion of corn for the production of meat and of animal and poultry products.

The demand for corn, therefore, is largely the demand from the producers of livestock for corn for feed. Figure 52 shows the percentages of total corn fed to different classes of live-

stock in two five-year periods, 1925–1929 and 1942–1946. The relative demands for corn from the different kinds of livestock and poultry shown probably differ considerably from the relative quantities fed to each. Because of the number of factors involved, it is not possible to measure these relative demands with much accuracy. But the differences in the methods of producing, feeding, and marketing the different livestock point to differences in relative demands. For example, some animals are fed corn for finishing purposes; others are fed corn largely for maintenance purposes. If corn supplies are short and prices are high in relation to the demand and also in relation to livestock and livestock products' prices, feeding for finishing will be cut down much more than feeding for maintenance. This indicates that the demand for corn to feed hogs or cattle would be less than the demand for corn to feed work stock and to winter breeding herds. Hence the relative demand varies for corn for dairy cattle, poultry, or sheep. Also the relative demand may affect prices differently, according to how the demand is supplied. Nearly all the corn fed to hogs is raised on the farms that produce the hogs, and the quantity bought is relatively small. On the other hand much of the corn fed to dairy cows and poultry moves through the commercial corn markets where the price of corn is registered, if not actually made. Hence the demand for corn for dairy cows and poultry probably affects prices out of proportion to the percentage such supplies are of the total corn production. Some students of the situation think that the demands of other livestock and poultry are first met, and hogs get what remains. This assumption, if true, supports a conclusion that the demand for corn for feeding hogs does not affect corn prices to the extent that the supply consumed by hogs would lead us to expect.

Two series of corn prices are adopted in various studies having to do with corn. One of these is the price of corn at terminal markets where large quantities of corn are bought and sold. This may be the price at one market or the average

for a number of markets. It may also cover a specific kind and grade of corn, as Number 3, Yellow, or it may be an average of all grades sold. The market price of a specific grade of corn at Chicago is used in Fig. 51. The other series covers the prices paid by buyers at local markets, mostly country elevators, and it is generally called the local farm price. Prices being paid about the fifteenth of each month are reported by a representative number of these buyers. These reports go to the state offices of the Agricultural Estimates Branch of the Bureau of Agricultural Economics. The reported prices are listed by counties and crop-reporting districts. County and district reports are used to compute state averages. These are sent to the Crop Reporting Board in Washington with a recommended state price and official estimates of state, regional, and United States prices are made. The average prices shown in Fig. 50 are the estimated prices for the United States.

For some purposes market prices are more desirable for they are available for short periods by days and even hours, and they also show prices by different grades. For other purposes the farm price is preferable for it shows the geographical distribution of prices. In general the trend from month to month and season to season of these two series is the same. The question then arises as to which is the basic price. Do farm prices determine market prices, or do market prices determine farm prices? Is the Chicago market, which is the largest and most important market for corn, both cash and futures, a basic price-determining point or is it only the most important price-registering point?

Sale of corn. As previously pointed out, the size of the corn crop, the supply, is the principal factor in determining the changes in the seasonal average price of corn. Most of the corn produced is fed on the farms where it is grown. The price of corn is based on the prices paid for the corn that is sold. The United States Department of Agriculture makes estimates of the yearly sales of corn by farmers and also of the percent-

ages of the sales made each month. For the period 1924–1946 the percentage of the corn harvested for grain that was sold each year ranged from 20.4 to 25.3 per cent in all crop years except four. These four were the drought years of 1930, 1934, 1935, and 1936, when the percentages sold were 19.0, 13.3, 19.8, and 17.1, respectively. Apparently the amount of corn sold by farmers varies with the size of the crop. On the other hand, there is a wide range in the percentages of the corn sold by farmers that moves through the principal terminal markets, where most of the corn going into the commercial supply is handled. (Fig. 53.) This percentage ranged from a low of 30 per cent in the crop year 1931 to a high of 69 per cent in the crop year 1934. It is significant that the years when these percentages were lowest were those when the seasonal average price dropped sharply from the preceding year or when prices were very low. These years were 1925, 1931, and 1932. Percentages were highest in 1927, 1934, and 1936, when the seasonal average price advanced sharply over the preceding year.

Obviously the prices paid to farmers for corn reflect market prices and tend to follow them up and down. However, there is a large market outlet for corn other than through these large terminals. This is the local market made largely by livestock producers who have livestock to feed. With low or declining prices they tend to buy more of the corn for sale. With rising prices they tend to restrict their purchases and more of the corn goes to the terminal markets. Thus the local market, by controlling the percentage of corn going to the terminals, tends to set the seasonal average price. But since the short-term terminal prices are those at which current receipts will clear, these local markets determine to very large extent the fluctuations within the season.

Effect of government controls. Since 1933 there has been a new factor in the corn market which has tended to change the old relationships between seasonal production and seasonal prices and also the trend of prices during the season. This

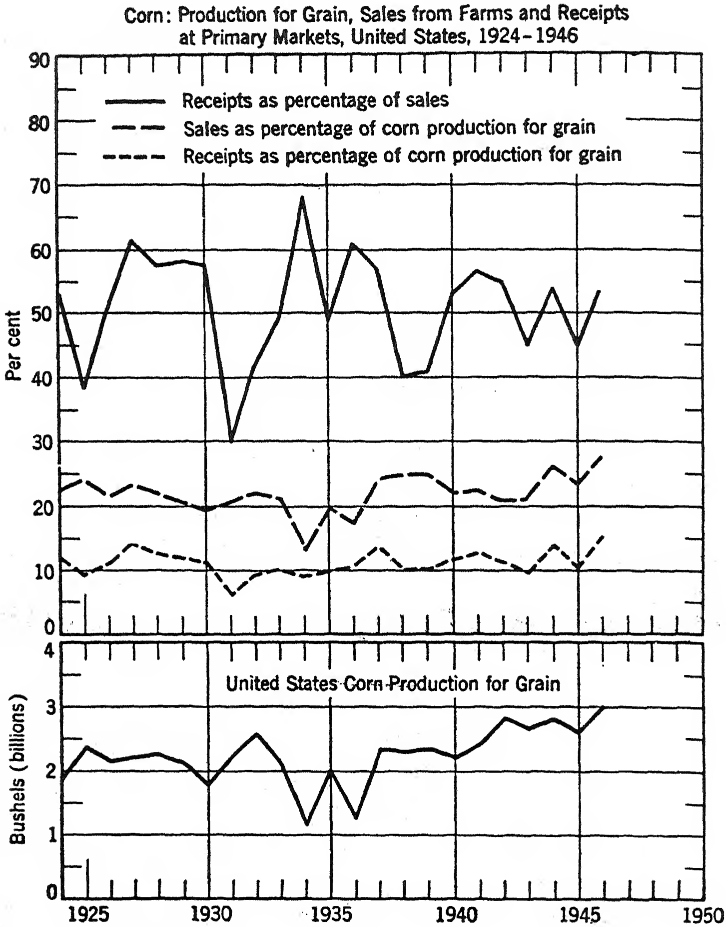

FIG. 53. The percentage of corn harvested for grain that is sold by farmers tends to be fairly constant from year to year, but there is a wide variation in the percentages of corn sold by farmers that goes through terminal markets.

factor is the action of the federal government to influence or control prices. These actions have included making loans to farmers on corn at higher price levels than the early seasonal level would otherwise have been, in order to raise or support the seasonal average price. This was the prevailing action from 1933 to about 1941. During the period 1941 to 1943 a somewhat reverse policy was followed to hold down the price of corn by selling the large stocks of corn and other grain accumulated under the loan and purchase policy of earlier years and by establishing relatively low ceiling prices under price control. The aim of this policy was to encourage the production of meat animals and poultry and related products. Following this was a policy of encouraging increased production by increasing ceiling prices and establishing price supports to prevent any sharp drop caused by the increased production.

The effect of the prewar loan policy was to hold up the price of corn in the years when loan and owned stock were being accumulated and to hold down prices when these stocks were disposed of. The latter effect was concealed, however, because of the conditions that arose later that were unforeseen when the stocks were being accumulated. The 1934 drought took care of the loan stocks of 1933, and war demands took care of the stocks accumulated from 1938 to 1941. The problem of disposing of such stocks without depressing prices has not yet been faced. The stocks accumulation activities from 1938 to 1941 also seems to have disrupted the former relationships between corn production and livestock production. Corn put under loan apparently passed out of the picture so far as affecting the livestock operations on such farms. In other words, the production of livestock and poultry during these years was less than it ordinarily would have been from the supplies of corn produced, or extra corn was produced that farmers did not include in their livestock program.

The policy of holding down feed grain prices to encourage the production of meat animals and poultry and of dairy prod-

ucts established ceiling prices on corn at low levels in relation to livestock ceilings and produced an enormous increase in numbers of livestock and poultry. From this situation arose a "black market" in corn so extensive that all prices shown during this period are much below the actual prices paid for most of the corn that was sold. Ceiling prices on corn had to be successively raised. Stocks of corn were depleted, and a new policy of encouraging production and support prices followed. When ceiling prices were finally removed corn prices shot up along with nearly all other farm prices and reached levels more nearly in line with the advancing price level and with consumer incomes as reflected in the prices of livestock. A more detailed discussion of this period and of the outlook for coming years as related to corn and hogs will be found in Chapter XXV.

Another development during the war years that tended to affect both the utilization and the price of corn was the large expansion in the production of commercially mixed feeds, especially dairy and poultry feeds. As a result of the high prices for meat animals and poultry and for dairy products and eggs, and as a result of the growing appreciation on the part of producers of the value of expertly mixed and balanced feeds, a wide market for such feeds developed. With liberal margins allowed by the Office of Price Administration between the cost of ingredients and the price of feed and with an almost insatiable demand to meet, the number of plants expanded rapidly and the facilities of existing plants were enlarged. There are no figures available showing the output of commercially mixed feeds or the quantities of different grains in these feeds. There are some records, however, of the number of plants. According to information obtained by the War Food Administration in connection with the licensing of feed mixers, there were in 1942 some 2200 primary mixing plants including those engaged exclusively in the manufacture of mixed feeds and an unknown number of plants producing mixed feeds as a side line. In 1944 there were nearly 6000

plants licensed under War Food Order No. 9, not including plants operating exclusively as custom mixers. During the years of greatest demand for feeds, after the accumulated stocks of corn and wheat had been exhausted, these mixing plants were the keenest buyers of all kinds of grain and especially of corn, not only at the terminal markets but direct from producers. Since price ceilings on grains were in effect during all this period, this competition, even if not a factor in maintaining the "black market," resulted in many arrangements and "deals" of a peculiar nature calculated to bring grain supplies to feed-mixing plants. It is highly probable that even with lower prices and less profitable operations the use of such feeds by dairymen and poultry producers will continue on a scale much above that of the prewar years and that the commercial feed-mixing industry will continue as an important factor in the corn market.

COMPETITION AMONG FEED GRAINS

Since the greater part of the three principal feed grains, corn, oats, and barley, are used as livestock feed, it is to be expected that there will be similarity among the three in price changes from year to year. The prices of all three are affected by changes in the general price level. Moreover, since the total tonnage of corn produced greatly exceeds the combined tonnage of the other two grains, it is obvious that small or large crops of corn will affect the prices of oats and barley more than small or large crops of these will affect the price of corn. Also, there are specific demands for oats and barley that do not apply to corn, and changes in these demands may result in changes in the prices of one or the other of these that are not accompanied by similar changes in corn prices.

In all years substantial quantities of wheat are fed to livestock and poultry, and in some years these quantities are large. Heavy feeding of wheat usually takes place during years when corn is in short supply relative to livestock and

poultry numbers and the price per pound of wheat is not greatly different from that of corn. Unusually heavy feeding of wheat took place during the years from 1942 to 1945 when supplies of all feed grains were short relative to demand. The years from 1940 to 1946 saw a marked increase in the production of sorghum grains, which are used principally as feed for livestock and poultry (see Table 4). Large quantities were used as a substitute for corn in mixed feeds and also in the production of alcohol and distilled spirits. Usually the farm price per pound of sorghum grain is less than the farm price per pound of corn, but during the war years, because there were no ceiling prices and no restrictions on the uses of sorghum grains, prices reached levels considerably above those of corn.

THE GEOGRAPHY OF CORN PRICES

The price of corn varies widely over the United States. This is seen in Fig. 54 which shows the average farm price of corn for the ten years 1925–1934 in different areas of the country. These prices are shown by isotimes, or lines of equal price, depicting the difference in prices received, just as isotherms, or lines of equal temperature, are employed to show variations in temperature on a weather map. The lowest average prices prevailed in a circle of counties in southwestern Minnesota, eastern South Dakota and southeastern North Dakota. A much larger area, taking in most of the states of Minnesota, North and South Dakota, Nebraska, and the western half of Iowa, had the next lowest average. Somewhat higher but still relatively low prices were evident throughout the rest of the north central states, excluding Wisconsin and Michigan to the north, most of Ohio to the east, and Missouri to the south. From this area to all points of the compass higher prices are shown but with varying degrees of increase. The highest prices are shown for the areas farthest from the Corn Belt.

Although corn prices in the deficit areas are usually higher than prices in the corn surplus-producing states by the amount

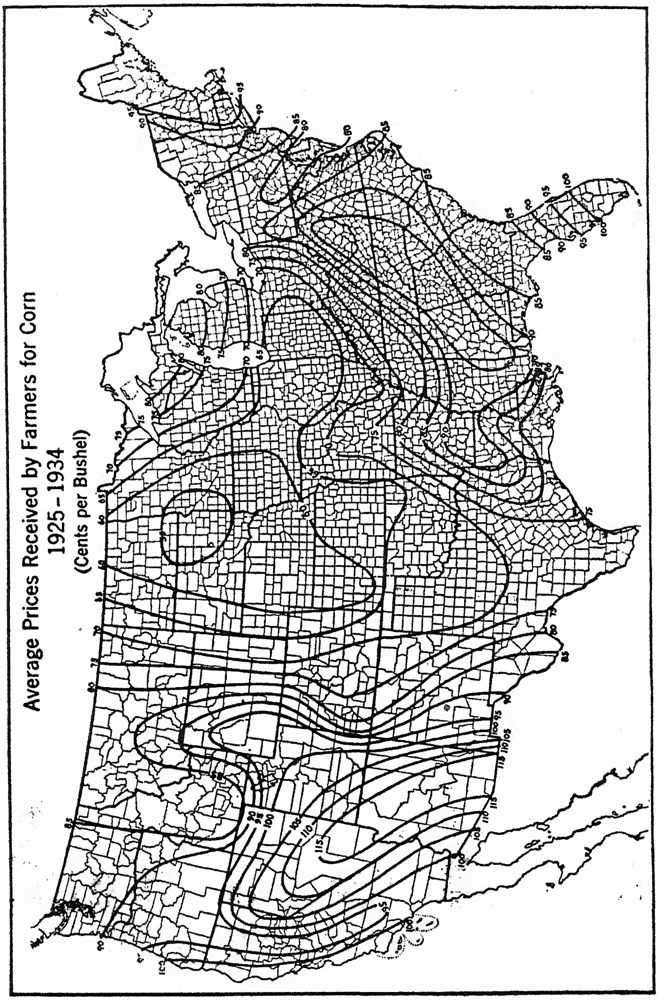

FIG. 54. Farm prices of corn are lowest in the northwestern part of the main corn-producing area. From this low-price area, prices increase in all directions and are highest in areas farthest removed from the Corn Belt.

of freight and other marketing costs, variations in production by states bring about alterations in the relation of prices among the several states. In years of severe shortages in surplus-producing states, as in the 1934–1936 drought period, the usual direction of flow of corn to central markets may change and corn may be shipped into normally surplus areas. Prices in these areas may then be higher than in normally deficit areas. For example, corn prices in South Dakota are normally well below those in the eastern seaboard states, but in 1934–1936 they exceeded the prices in the deficit eastern area. The variations in local supplies are largely responsible for the fact that the prices do not show a constant margin of difference.

The range of corn prices throughout the United States normally amounts to about 100 per cent from the lowest to the highest prices. This is accounted for by variations in the intensity of production and the local demand for corn. In the western Corn Belt, from which deficit areas must draw corn over great distances, local corn prices naturally are at lower levels than in other parts of the country to which this corn is shipped. The market price to the consumer for shipped-in corn in any locality is about equivalent to the cost of corn plus freight and handling charges.

SEASONAL VARIATION IN CORN PRICES

Corn is grown generally over the United States, especially in that large part that lies east of the Rocky Mountains, but there is considerable variation in the growing season. Along the Gulf Coast planting starts in March and early corn matures in August. The average date of planting becomes successively later from the south to the north, with about the middle of May the peak period of planting in the Corn Belt proper and the latter part of May or early June along the northern border areas. However, in the north central states there is not the difference in the date of harvest that there is

in the time of planting. The potential growing season for corn, from the last killing frost in the spring to the first killing frost in the fall, grows shorter from south to north. To offset this difference in the length of growing season, varieties of hybrid corn have been developed that can be planted later in the north than in the south and still mature sufficiently early in the northern areas.

The corn that goes into the commercial supply, which is reflected in the movement through terminal markets, comes almost entirely from corn husked in the field from standing stalks. There is, however, in the southeastern Corn Belt a considerable volume of sales to local industries and farmers of corn husked from the shock. Corn differs from wheat in that very little of the corn harvested in the southern states gets into the commercial supply. Early harvesting of corn in southern United States has practically no influence on the cash corn market. The corn that does supply this market comes largely from the Corn Belt, and the movement of new crop corn from the Corn Belt states does not get under way until October. Hence the corn marketing year generally extends from October 1 to September 30 of the following year. The supply for that year is the carry-over of old corn on October 1 and the crop harvested in the marketing year beginning in October.

It is usually the latter part of October or early November before new crop corn begins to get into the commercial supply in considerable volume and to show up in receipts at terminal markets. The new crop, however, begins to affect the corn price structure much earlier than this. Information as to the prospects for the new crop become available in March when the Department of Agriculture's report on intentions to plant is made. This gives an indication of the corn acreage for the following season. Not, however, until about July 10 is the first official estimate made of acreage for harvest and forecast of probable yield as indicated by conditions on July 1. Hence the prospective new crop does not begin to affect corn prices

until July. In some years, however, if weather during the planting and early growing season is very unfavorable and much of the corn is planted late, with the soil in poor condition, or if there is a severe and continuing drought over large areas, the price structure may be affected by this poor prospect earlier than July.

The first effect of the prospective new crop is not directly on the cash corn market but indirectly on the prices of futures in the speculative market. The cash grain market is determined day by day by the prices paid for corn sold at the terminal markets. The average price for any day is the average of prices at which the corn was offered for sale and sold. The normal movement of monthly average prices of cash corn over the marketing year is a decline from October to December or January, then a gradual advance to July or August, when the seasonal peak is usually reached, and then a moderate decline to the end of the marketing year in September. This is the normal movement in years when the size of the crop is not much different from that of the preceding year or from that of the following year and when there is no sharp change in the general price level. This normal price movement over the season is very largely in inverse direction to the changing volume of marketings over the season.

Years of abnormal price fluctuations occur when there are marked changes in the total United States corn crop from one year to another. These years are related directly to unfavorable growing seasons which result in greatly reduced total corn production compared with the crops of the preceding and following years. (See Table 39, 1934–1936.) In years of short crops the indications of such probable outcome usually become fairly pronounced in July. Poor prospects are first reflected in an advance in December corn, the first new crop future. The normal spread between July cash corn and the December future is about equal to the spread between the previous December and current July cash corn prices. As the

July cash–December future spread narrows, cash corn sellers become less anxious to sell and buyers more anxious to buy, and cash corn advances. As the season advances and the damage to the crop grows or becomes more evident, December futures continue to advance and the spread between cash corn and the December futures grows narrower and may entirely disappear. But, since old corn in August or September is worth nearly as much, pound for pound, as new corn in December, allowing for carrying charges, it is unlikely that the December future will exceed the cash price for any considerable period. Thus the trend of monthly cash prices in such years is upward from July to December instead of downward as in a normal year. And since such years are usually years of the heaviest speculation in corn futures, cash corn generally reaches the highest point of the marketing year in December or January and makes no seasonal advance and may actually decline.

In years following these short crops an opposite movement of prices occurs if corn production promises to be back about to normal. With corn prices at a high level in July as a result of the short crop of the preceding year, a planting and early growing season that promises an average or near average crop is reflected in a December future price that is fairly well in line with December cash corn prices in years of average crops. The spread between July cash and December futures is unusually wide; buyers of cash corn become cautious and sellers more eager, and the price of cash corn declines more than seasonally from July to December. In such years the sharp drop in corn prices makes farmers disinclined to sell new crop corn, and the market movement of such corn is delayed. Also, the drop in livestock numbers and production caused by the short crop of the previous year decreases the local demand for corn. As a result the price of corn may continue to decline for several months after December and make less than the normal seasonal rise to July or August.

MONTHLY DISTRIBUTION OF MARKETINGS

There are two sets of data showing the monthly distribution of corn marketings within the corn-marketing year. One of

TABLE 27

PERCENTAGES OF MONTHLY DISTRIBUTION OF CORN MARKETINGS

	1924–1932		1933–1942	
	Receipts at Twelve Markets	Estimated Sales by Farmers	Receipts at Twelve Markets	Estimated Sales by Farmers
October	8.0	7.8	10.8	8.9
November	7.7	9.5	10.5	11.0
December	11.5	13.2	9.9	10.7
3 months	27.2	30.5	31.2	30.6
January	10.8	11.5	7.9	8.6
February	10.4	10.3	7.0	7.8
March	8.4	7.6	7.3	7.8
3 months	29.6	29.4	22.2	24.2
April	6.4	6.2	7.3	7.1
May	6.3	6.7	7.8	7.5
June	8.3	7.0	8.1	7.4
3 months	21.0	19.9	23.2	22.0
July	7.8	6.7	7.9	7.0
August	6.9	6.8	7.7	8.3
September	7.5	6.7	7.8	7.9
3 months	22.2	20.2	23.4	23.2
Yearly total	100.0	100.0	100.0	100.0

these is the estimated percentages of corn sold by farmers each month, and the other is the percentage of the yearly receipts received at twelve primary markets each month. Table 27 shows the percentages by months and quarters from each

source covering the averages of two periods of years. The first period is for the nine years 1924–1932, and the second for the ten years 1933–1942. The first period was before the inauguration of government actions that tended to influence or control the production and marketing of corn. The second period is one when such government programs were in effect but no price ceilings had yet been established that largely eliminated monthly variations in prices within the season and also the effect of changing prices on the monthly distribution of sales.

This table shows a material shift in the distribution of marketings between the two periods with the proportion decreasing in the first half of the year and increasing in the second half. The most marked changes, however, were within the first half of the year. The proportion in the first quarter (October-December) increased and in the second quarter (January-March) decreased sharply. Within the first quarter October and November increased, whereas December declined; the decreases in the second quarter were mostly in January and February. For the three winter months, December, January, and February, the twelve market receipts dropped from 32.7 per cent to 24.8 per cent and the farm marketings from 35.1 per cent to 27.1 per cent.

The reasons for these changes are not entirely clear. The increased proportions in October and November are definitely associated with large carry-overs of corn on October 1, and these large carry-overs with the quantities of corn sealed under loans and government owned. The sharp decline in the winter months appears to have been due largely to the fact that large quantities of corn that normally would have been marketed during those months were sealed under loan. In the first period the corn sold during the marketing year was largely corn harvested in the year of the beginning of the marketing year. In the second period large quantities of corn marketed in the early months of the marketing year were corn that had been harvested one or more years before the

beginning of the marketing year. The relationships between supplies and prices that seemed fairly clear during the first period were largely obscured or eliminated during the second. This is partly accounted for by the fact that the seasonal distribution of marketings changed materially but the seasonal movement of prices tended to follow the former pattern.

CORN PRICES AND SPECULATION

The monthly and seasonal corn prices used in this chapter are the prices paid to farmers for corn that was sold at local markets or the prices for actual corn that was bought and sold on the cash grain market of the Chicago Board of Trade. In addition to purchases and sales of actual corn there are the purchases and sales of corn for future delivery, so-called *corn futures,* that exceed by many hundredfold the operations on the cash corn market. This buying and selling of corn futures is the speculative corn market. To the extent that the buying or selling is for the purpose of hedging commitments to buy or sell actual corn or corn products, it is not speculative. To the extent that such operations are conducted with no intention or expectation of delivering or receiving actual corn, they are entirely speculative.

The statement is often made that the price of corn is determined by speculators in the corn pit of the Chicago Board of Trade. There is no question but that speculative activities have considerable influence on day-to-day changes in cash corn prices. At times they may increase or decrease the average monthly price of cash corn from what it otherwise would have been and may affect the seasonal trend of prices, but there is little reason to believe that they cause the seasonal average price to be greatly different from what it otherwise would have been. Although speculative dealings are in corn futures, there are occasions when the settlement of these futures contracts affects materially the price of cash corn for the period of several weeks and hence the average monthly

price of cash corn. This occurs when there is a market "squeeze" caused by excessive short sales of a specific future in relation to the quantity of actual corn available for delivery on such contracts as the closing date of the future approaches. The "shorts" go into the cash grain market to buy corn to deliver in competition with actual corn users, and the price of corn may go considerably higher than it would have with only consumer buyers in the market. Also, if there is a large movement of corn in prospect but only moderate current receipts, heavy sales of futures may weaken the whole price structure and cash corn may sell below what consumer buyers would otherwise have paid for the current supply. On the contrary, if the corn crop for the current year promises to be greatly reduced, there is generally a strong bull market in new crop futures. This results in raising the price of December futures and the average price of December cash corn to a level too high and hence retards the movement of corn into commercial channels. Corn prices do not make the usual seasonal advance after December or January and may actually decline. In such years speculative activities are largely responsible for the deviation from the usual seasonal trend.

GOVERNMENT CROP REPORTS

Since the condition and development of the current year's corn crop is an important price-influencing factor after July 1, both for old corn and for new crop futures, there is a strong demand for such information. There are numerous sources of such information such as weather reports, newspaper reports, and reports issued by grain commission houses. The most extensive and detailed report and the one given most general credence is the *Monthly Crop Report* issued by the Crop Reporting Board of the United States Department of Agriculture.

The first of these reports relating to corn is the intentions to plant report issued during the latter part of March each year. Some 40,000 farmers, well distributed over the United

States, report the acreage of various crops on their own farms the year before and the acreage of the crops they expect to plant in the current year. When these reports are summarized and interpreted by the Crop Reporting Board on the basis of past experience with this inquiry, a very good indication is obtained of the number of acres that are likely to be planted to corn. Extensive adverse weather during planting time will result in a smaller corn acreage than indicated by the March intentions report. This report, however, enables the individual farmer to adjust his farming plans in light of what farmers generally are expecting to do.

In May and June crop reports are issued that give general information on weather conditions in important corn-growing areas and the progress of preparing the fields and planting corn, but it is not until about July 10 that the first complete report on corn is issued. This includes an estimate of the acreage of corn planted and the acreage to be harvested, and a forecast of the probable yield and of total production. The estimates on acreage are based on reports from approximately 60,000 farmers. These reports are quite similar to the ones made in March on intentions to plant. The July estimate of acreage for harvest is used in making forecasts of the size of the corn crop in each successive monthly report through November. This acreage multiplied by the forecasted yield per acre made each month gives total production.

The July forecast of yield per acre is based on a statistical interpretation of the condition of the growing crop on or about July 1, as reported by approximately 20,000 crop correspondents from all parts of the United States. These correspondents, generally known as "crop reporters," are mostly farmers, and all serve voluntarily and without pay. On the first of each month from July through the growing season they send in reports on the condition of the corn crop. A reporter's estimate on condition is a composite of the corn outlook in his locality expressed as a percentage of "normal." From the way the system works out in practice, the crop reporters ap-

parently consider a "normal" crop as somewhat above average but not a full or perfect crop.

The yield per acre adopted by the Crop Reporting Board is based on the usual relationship of the reported condition figure to the final yield obtained over a period of years. For example, if the July condition of corn is reported by crop correspondents to be 80 per cent of normal for a given state, the forecast of yield per acre will be approximately the average yield obtained in previous years in that state when the condition was reported as about 80 per cent. The interpretation makes allowance for any pronounced trend or change in the relationship of reported condition to final yield per acre. For example, in determining the corn yield allowances are made for the increasing proportion of the acreage planted to hybrid corn, which usually out-yields open-pollinated varieties by as much as 20 per cent. The influence of hybrid corn is about stable in all the Corn Belt where about 97 per cent of the crop is hybrid. Outside the Corn Belt the increasing use of hybrid corn is a factor in estimating the crop. In the language of the statistician, graphic correlation technique is used in interpreting the reported condition.

During the vegetative development of the crop, reporters can estimate corn prospects more accurately in terms of condition than in terms of probable yield per acre. After the ears are fully formed, which is about September 1 in the early states of the Corn Belt and before October 1 in all states, crop reporters also estimate probable yield per acre in bushels. On November 1, they report their estimate of the average yield per acre of corn in their own localities. In November a survey is made in which farmers report for their own farms the acreage and production of corn for grain and silage, the acreage for forage, and the acreage that failed. In October, with the help of the rural mail carriers, a survey is made in every state covering the acreage of all crops harvested in that year. A large sample is obtained covering about 160,000 farms in the United States. The final estimate of acreage for the year for

all crops is based largely on the interpretation of the returns from the rural carriers' survey, with other information on acreage such as assessors' enumerations, crop meter measurements, and industry reports on contracted acreage. On the basis of all information available up to December 1, an estimate of the acreage of corn harvested, the yield per acre, and production according to utilization, as for grain and silage, is made and published in the December crop report. It is to be noted that the December report is an actual estimate of the size of the corn crop, whereas the reports in earlier months were only forecasts based on indications available at the time the reports were made.

The crop-reporting service was developed in response to continuous and insistent demand for unbiased information on crop production and other matters pertaining to agriculture which no other agency has been able to supply. For years before official crop reports were issued there was agitation on the part of farmers and farm leaders for accurate information regarding crop production prior to the time they marketed their crops. Even before 1839 farmers resented the profits made by dealers and speculators in farm products as a result of the circulation of misleading crop reports. During the 1850's several farm papers and county and state agricultural societies endeavored to meet this need for current information on crop production. Finally in 1866 regular monthly reports were made on the condition of the crops during the growing season, and annual reports on acreage yield per acre, total production of important crops, and numbers of livestock on farms on January 1 were begun by the newly formed United States Department of Agriculture. Even in the early years of the organization information concerning the production of crops and livestock in foreign countries was obtained and regularly published by the department. The monthly crop reports give farmers, dealers, and speculators, alike, information concerning crop prospects and production and thus place them all on an equal footing.

SHRINKAGE AS RELATED TO THE PRICE OF CORN

Farmers who sell corn are naturally interested in knowing the most profitable time to sell. As heretofore shown, the trend of corn prices in normal years is downward from October to December or January and then gradually upward to July or August when the highest prices for the year are usually reached. But during this time the corn is shrinking in weight, and if the farmer is to break even on a given lot of corn the advance in price must be larger relatively than the shrinkage in weight. Experiments made in Iowa and Illinois a good many years ago indicated that, on an average, corn picked early in November will shrink about 3 per cent in November, 2 per cent in December, 1 per cent in January, 1 per cent in February, 1 per cent in March, 3 per cent in April, 3 per cent in May, 2 per cent in June, and 1 per cent in July. This gives a normal shrinkage of about 17 per cent from cribbing time in November until the middle of the following summer. Of course, there is considerable variation in the years. If the fall is dry and the corn is unusually well matured, the shrinkage may amount to only 9 or 10 per cent, whereas the shrinkage may be as high as 25 per cent following wet, cold falls. The monthly figures represent normal conditions. In some years, however, the really heavy shrinkage starts in late March, in other years in April, and occasionally not until June. Usually, though, late April and May is the time of the heaviest shrinkage in corn.

In order to cover the normal shrinkage of 17 per cent from November to the following summer, the price in the summer would have to be at least 20 per cent higher then the November price. By months, the percentage of increase over the November price to cover the cumulative shrinkage would be 5 per cent in December, 6 per cent in January, 8 per cent in February, 9 per cent in March, 12 per cent in April, 16 per cent in May, 19 per cent in June, and 20 per cent in July. If allow-

ance is made for interest and insurance, some loss from rattage, and overhead investment in the crib, the July price would have to be about 25 per cent higher than the November price to bring a return equivalent to what would have been obtained in November. Since 1920 the farm price in July averaged about 28 per cent higher than the November price for ten fairly normal years. These were years when there was no marked difference in the size of the crop compared with either the preceding or following year and in which there was no significant change in the price level during the period. Since there were only about ten such years in the years from 1920 to 1946 it would seem that what happens to prices in normal years is of less importance than what happens in abnormal years.

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CHAPTER XXV

THE INTERRELATIONSHIP BETWEEN CORN AND HOGS

There is a close relationship between corn production and hog production. This relationship arises from the fact that a large part of the corn produced is fed to hogs and that corn is the principal hog feed in the important corn-growing states. Prior to the drought years of 1934–1936 it is estimated that about 40 per cent of the corn fed was fed to hogs. Since 1934 there has been a substantial increase in corn fed to hogs. The percentage has remained about constant. (See Fig. 52.) There has been a general Corn Belt increase in total bushels harvested between 1936 and 1946. This close relationship is shown by Figs. 55 and 56 which show the distribution of the acreage of corn and of the number of hogs in the various states. The marked concentration of both corn and hogs in the Corn Belt, especially in Iowa, southern Minnesota, eastern Nebraska, southeastern South Dakota, northern Missouri, northern Illinois, northern Indiana, and northwestern Ohio, is very noticeable in these two figures.

In no other region of the world are hogs and corn so closely interrelated as they have been and still are in the Corn Belt of the United States. In other important hog-producing countries, such as Canada, Denmark, and Germany, hogs are fed relatively little corn. Other feeds such as potatoes, barley, and skim milk form the basis of the hog ration. This same situation prevails in areas of the United States outside the Corn Belt, with peanuts, grain sorghums, barley, low-grade wheat, and by-product and cull feeds important in different areas. Partly because of the use of corn as the principal hog

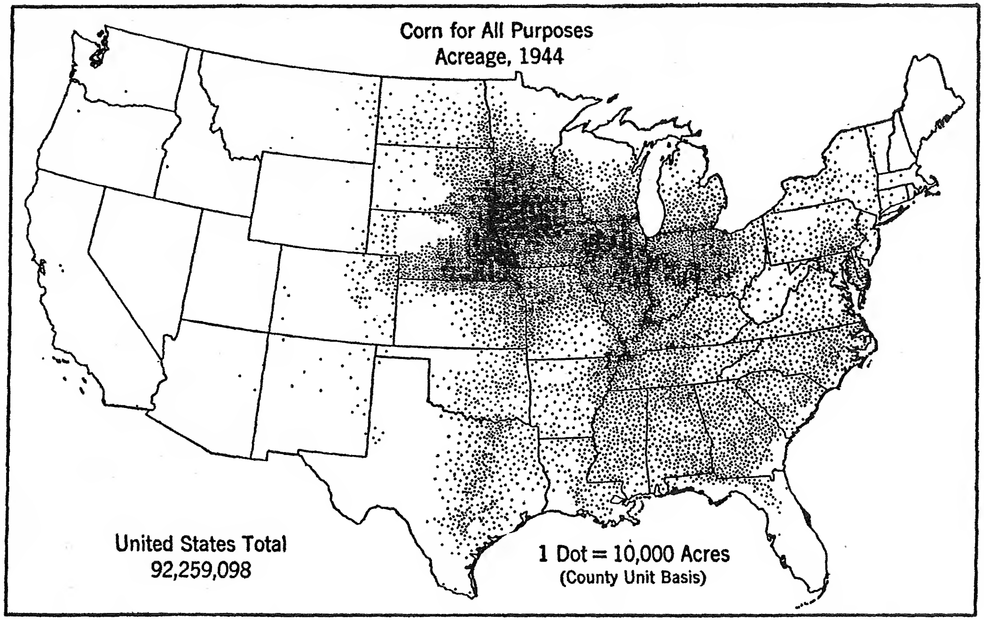

FIG. 55. The dots on this chart indicate the relative acreages of corn in different states and regions. The marked concentration of acreage in the leading Corn Belt states is clearly shown. Because of higher yields in the Corn Belt, production is even more concentrated, relatively, than acreage.

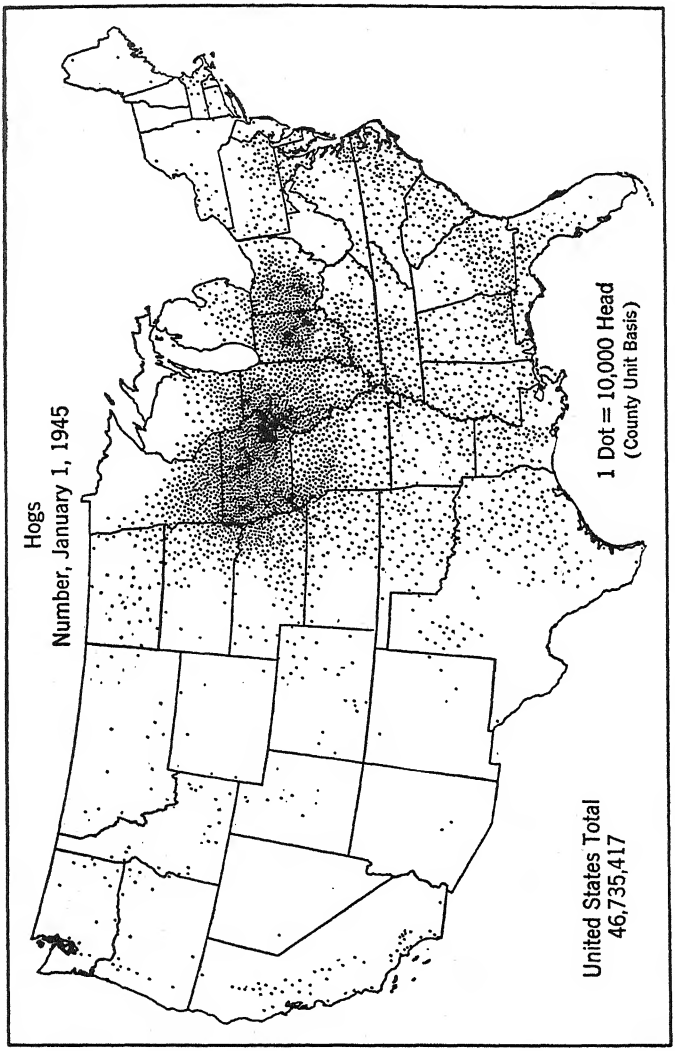

FIG. 56. The dots on this chart show the distribution of hogs in 1945. Comparison with Fig. 55 shows that hogs and corn are concentrated in the same areas.

feed, the methods of hog production and the type of hog produced in the Corn Belt are quite different from those in other countries and in other areas of the United States.

Corn and hog production in the United States shifted gradually westward during the last half of the nineteenth century and the first three decades of the twentieth century as the middle west was settled and developed. In 1840 the center of hog production in the United States was in northeastern Kentucky. By 1870 this center was in southern Indiana, by 1900 in west central Illinois, and by 1930 in northeastern Missouri. Since 1930 the westward movement has been checked by a tendency for a reverse movement.

The close relationship between hog production and corn production is shown by the trends of the two during the last thirty years in the west and north central states. From 1910 to about 1933, there was a marked expansion in the number of hogs in the western Corn Belt, notably in Iowa, southern Minnesota, eastern South Dakota, and eastern Nebraska (see Fig. 57). The increase in corn acreage in this area was very marked from about 1908 to 1932, and it was followed by a sharp increase in hog production. Between 1908 and 1932 corn acreage in the five north central states, Iowa, Minnesota, North Dakota, South Dakota, and Nebraska, increased more than 60 per cent from 20,640,000 acres to 34,000,000 acres. Since total corn acreage in the United States changed very little during this period, the proportion of the total acreage in these five states increased markedly. The number of hogs on farms increased about 75 per cent from 1910–1914 to 1930–1934.

As a result of the drought period extending from 1930 to about 1938, which was more severe and more prolonged in the Great Plains states than elsewhere, the movement of corn acreage and hog numbers was reversed. By 1940 the acreage of corn in the five north central states, which had reached a peak of 34 million acres in 1932, was down to less than 24 million. Corn production was down from 1248 million bushels in 1932 to 824 million bushels in 1940 after recovering from

the low point of 312 million bushels during the drought years. During the same period the number of hogs, which had reached a near record total of 25 million head in 1932, dropped to about 11 million in 1935 and was up to over 18 million in 1940.

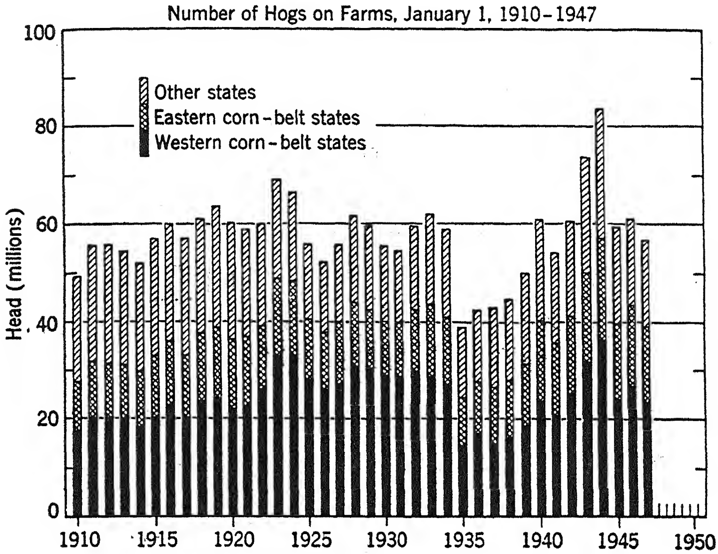

FIG. 57. The number of hogs in the west and north-central states increased markedly between 1910 and 1934. The drought years of 1934 and 1936 cut hog production in these states very sharply, especially in the states west of the Missouri River.

Nearly all the difference between 1932 and 1940 was due to the smaller numbers in the western half of the Corn Belt.

Since corn is the principal hog feed, changes in the price of corn are principally responsible for changes in the cost of raising hogs. Hence a close relationship exists between changes in hog production and changes in the relationship between hog prices and corn prices. The usual way of expressing this relationship is by means of the ratio of the price of hogs to the price of corn. In other words, the hog-corn ratio is obtained

by *dividing the price of hogs per hundred pounds by the price of corn per bushel.* (See Table 40.) Only in recent years, however, have a considerable number of farmers thought in terms of ratios, and only in the last twenty-five years have farm advisers and students of livestock production dealt in ratios. Farmers think more in terms of the cost of corn required to

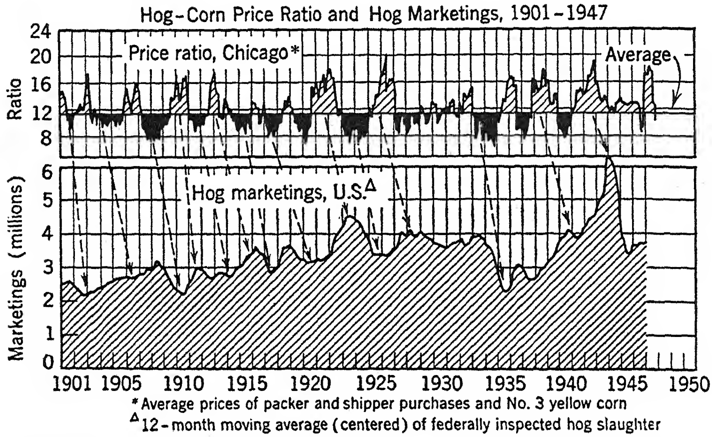

FIG. 58. When the hog-corn ratio is above average, hog production is increased. This increase is reflected in larger marketings of hogs one to two years later. Below-average hog-corn ratios have the opposite effect.

produce 10 or 100 pounds of hog. The old "rule of thumb" of 1 bushel of corn for 10 pounds of gain is still the guide of many farmers' thinking. But since the two factors in the hog-corn ratio are readily available currently, and since this ratio tends to follow the same course as a ratio obtained by dividing the price of 100 pounds of hog by the corn cost of producing 100 pounds of hog, it is now generally adopted. In most studies of changes in hog production this hog-corn ratio is a very important factor.

The changes in the hog-corn ratio and the changes in hog production as reflected in hog marketings over a long period

of years are shown in Fig. 58. In the upper section of the figure the periods when the ratio was below a long-time average are indicated by the black areas below the line and the periods of above-average ratios by the shaded areas above the line. In the lower section of the figure, hog marketings as shown by slaughter records are indicated. It will be observed

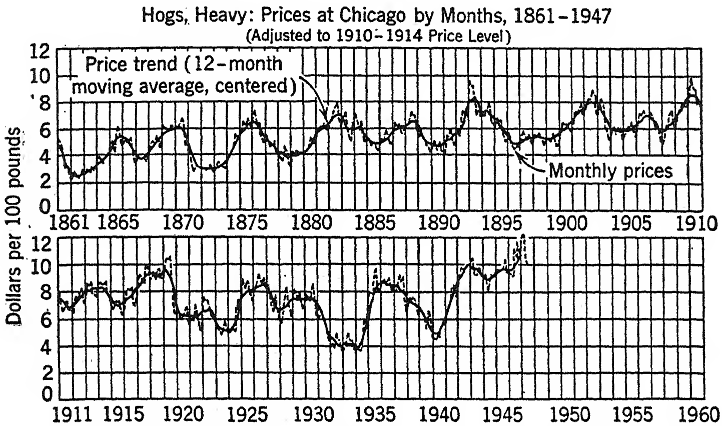

FIG. 59. Over a long period of years, the prices of hogs have moved up and down in fairly regular cycles. These ups and downs of prices tend to coincide with decreases and increases in supplies of hogs.

from the slanting arrows which extend from the upper section to the lower section that, when the ratio is below average, hog marketings tend to decrease one to two years later. When the ratio is above average, such marketings tend to increase one to two years after the ratio becomes favorable.

The alternating periods of above- and below-average ratios and the more or less regular alternating increases and decreases in supplies of hogs have given rise to the idea that these ratios and hog production move in cycles. These cycles in hog marketings are to be noted in the lower section of the figure, which shows that marketings tend to decline for one to two years and then tend to increase for a similar period. This

cyclical tendency is also evident in the hog-corn price ratio indicated in the upper section of Fig. 58, which shows that the ratio tends to be favorable for one to two years and then unfavorable for a period of similar length. The periods of large hog marketings tend to correspond with the periods of below-average hog-corn ratios; likewise the periods of small hog marketings tend to be associated with the periods of high hog-corn ratios. A complete cycle of hog production from one period of low marketings to another is usually three to four years in length, but some cycles are as long as five years.

It also appears that hog prices themselves tend to move in cycles of about the same length as the cycles of hog production, as shown by marketings. This cyclical tendency in hog prices is shown in Fig. 59, which gives monthly hog prices from 1860 to the present time. These prices have been computed to allow for changes in the general level of prices. By comparison of Fig. 59 with Fig. 58, it will be observed that the periods of high prices tend to correspond with the periods of small marketings of hogs, and the periods of low hog prices occur at about the same time as the periods of large hog marketings. In other words the chief factor in causing changes in hog prices is changes in the market supply of hogs, when prices are determined in an uncontrolled market.

This relationship between hog production (or supplies) and the hog-corn price ratio is a rather complicated one. Changes in the ratio may be caused by changes in the price of hogs, by changes in the price of corn, or by changes in both. If hog prices go up and corn prices are unchanged or if corn prices go down and hog prices are unchanged, the ratio goes up. On the other hand if either hog prices go down or corn prices go up, with no change in the price of the other, the ratio goes down. The widest movements in the ratio are in periods when prices of hogs and of corn go in opposite directions—hogs up and corn down results in very high ratios, and hogs down and corn up in very low ratios. However, the ratios

may go up or down with the prices of both corn and hogs going up or down together. All these different combinations of price movements have occurred over the period shown in Fig. 58. The largest swings in the hog-corn ratios have been associated with short corn crops and with periods of business depression.

The effect of the changes in the ratio on hog production is explained as follows: With the hog-corn price ratio fairly high and continuing so over a period of six months or a year, hog raising is stimulated. That is, on the basis of prevailing price relationships, it appears profitable for farmers to expand hog production. Because of the time involved in increasing production and occasionally because of feed shortages, one to two years elapse after the hog-corn ratio becomes fairly high before increased production is reflected in hog marketings. When the hog-corn ratio is low and continues low for some months, it becomes less profitable or unprofitable to raise hogs; therefore, the number is reduced. But it is one to two years before the reduced pig crops show up in smaller marketings.

Changes in the hog-corn ratio also affect the seasonal distribution of hog marketings and the average weights at which hogs are marketed. When the ratio is well above average and hogs are paying well for the corn being fed, hog producers tend to feed more corn per hog and thus to increase average weights. This additional feeding tends to lengthen the feeding period and to delay the seasonal movement to market. This increase in weights usually becomes evident shortly after the ratio becomes favorable, and the proportion of the seasonal supply marketed in the early months declines. Conversely, when the ratio is below average the quantity of corn fed per hog is cut down, average weights of hogs marketed are reduced, and the proportion of the seasonal supply marketed in the early months is large.

The effect of changes in the hog-corn ratio on the average weights of hogs marketed usually is held within a fairly narrow range of weights, with the yearly average of hogs

slaughtered running between 225 and 240 pounds. If the ratio is very favorable the average weight has gone up as high as 265 pounds. If the ratio is very unfavorable the yearly average may be reduced to 220 pounds or less. The heaviest weights are usually made in the years when the ratio is favorable because corn supplies are abundant and corn prices low. The lowest weights come in years when the ratio is low because corn prices are high as a result of a short crop. Likewise the effect on the monthly distribution of marketings is usually within fairly narrow limits. For example, in most years the number of hogs marketed in November and December is about the same as the number marketed in January and February. However, in some years of short corn crops and low ratios, the November-December total has exceeded the January-February total by as much as 50 per cent.

FACTORS AFFECTING HOG PRICES

A common statement with respect to hog prices, as with the prices of most other commodities, is that in an uncontrolled market they are determined by supply and demand. This means little to persons interested in hog prices unless the characteristic supply and demand conditions for hogs are adequately described. At the outset it should be stated that the physical operation of the hog industry proceeds from the producer to the packer and thence to the retailer and consumer, but the price-determining movement is the reverse, from the retail market to the wholesale market to the packing plant to the livestock market to the animal.

The supply of hog products moved into consumption during a given hog-marketing year (October 1 to September 30) always represents the approximate supply produced from hogs slaughtered during that year and not the quantity that can be moved at a particular price. The perishability of hog products, together with the speculative risks involved in holding and storage operations, make only limited carry-over feasible.

Likewise it is not practicable to hold hogs on farms for any considerable period after they have reached usual market weights. The hog crop produced in a given year is usually marketed within a period of twelve months, and the stocks of hog products accumulated in a particular storage season are moved into consumption before the next storage season begins. In these respects hogs are different from other agricultural products of nonperishable nature such as wheat and cotton.

The immediate demand for hogs is found in the hog markets where the buyers and sellers meet. This is a demand for a raw material to be processed, the various products going by different stages to the actual consumers. The ultimate demand for hogs, then, is the demand of consumers for the products of hog slaughter. The actual meeting place of this consumer demand and the supply, chiefly pork products and lard, is at the retail counter or at the hotel and restaurant table. The effective or organized meeting places are in the wholesale meat and provision markets of all kinds where sales are made to retailers and to buyers for hotels, restaurants, and institutions of various kinds.

It is important to recognize that the producer of hogs sells a raw product which is not in a form to be directly utilized by consumers but must be converted into numerous products for consumption. The price which the producer receives for hogs depends on the prices which consumers pay for the various hog products and on the costs of processing and distribution involved in converting live hogs into meat and lard. To understand the causes of the fluctuations in hog prices, therefore, it is necessary to study the changes in the retail prices of hog products and the variations in the spread of margin between the price of hogs and the retail prices of hog products.

In general it may be stated that the retail prices of hog products are determined by the quantity of such products available for consumption and by the incomes or buying power of consumers. The close relationship between changes in the

total value of hog products at retail prices in the United States and changes in national income is shown in Fig. 60. It is

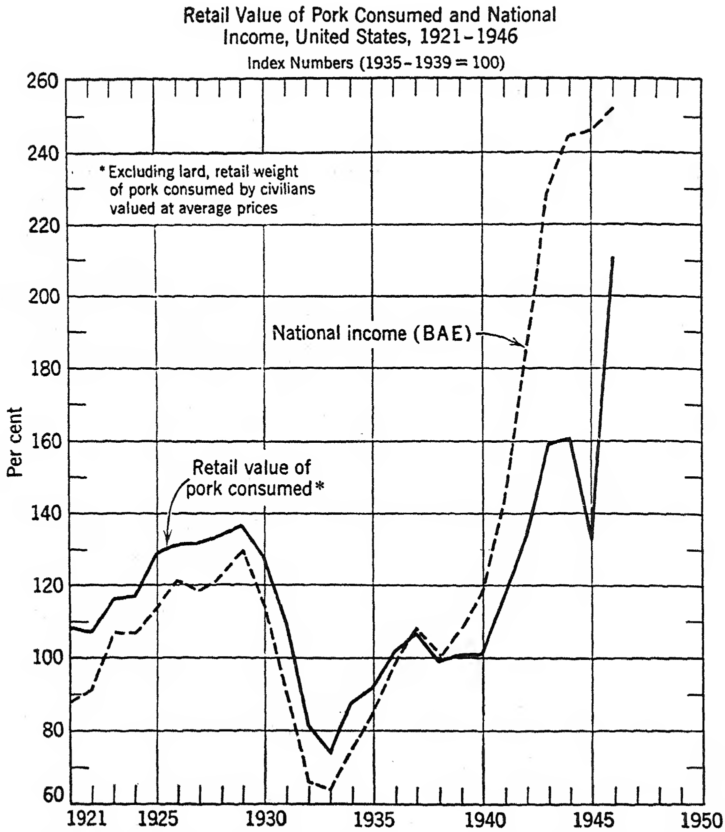

FIG. 60. During the last twenty-five years, changes in the retail value of pork consumed have followed closely changes in the incomes of consumers, except in the war years from 1943 to 1946 when ceilings on retail prices of pork were in effect which held down total retail value.

apparent from this figure that the changes in the total retail value are determined primarily by the changes in incomes of consumers except under conditions of controlled prices. If the

total amount of money spent for hog products by consumers is determined by the level of their incomes, it follows that the price per pound which they pay will be determined by the quantity of such products available and by their incomes, since the total value is the quantity multiplied by the price per pound. Studies of the spread between the price of hogs and the retail price of hog products indicate that processing and distributing costs for hog products are relatively stable from year to year but tend to reflect changes in wages and in costs of transportation. Thus it appears that the level of hog prices over seasonal periods or a year is determined chiefly by the prices which consumers in this country and in other countries pay for United States hog products. Since the supply produced in any year corresponds very closely with the domestic and foreign consumption of United States hog products, the two most important factors affecting hog prices are changes in incomes of consumers in this country and changes in the supply of hogs.

If production were maintained unchanged from year to year, hog product prices and, therefore, hog prices would fluctuate with changes in total incomes of consumers. But a given change in consumer income does not mean an equal change in hog prices. In recent years farmers have received about half of the consumer's dollar spent for pork. Consequently a 10 per cent rise or fall in prices paid by consumers, if all passed back to the producer, would mean a 20 per cent rise or fall in the price of hogs. During the war and postwar years from 1942 to 1946 when livestock was under price control and meats under price control and rationing, the relationship between consumers' incomes and total retail value of hog products did not prevail. The retail value was materially smaller than under a free market and, consequently, the prices of hogs were below what they would have been without government controls. Only in late 1943 and 1944 when hogs sold below ceilings were prices of hog products and total retail value of hog products about in line with consumers' incomes. When price

control was taken off in late 1946, retail prices and retail value advanced to about the levels expected with consumer incomes at the levels shown.

Figures 58 and 59 show the tendency for hog prices to be high when supplies are small and low when supplies are large. This is indicated by the relatively low prices in 1922–1923, 1923–1924, 1939–1940, and 1943–1944, when supplies were large. The sharp increase in the price of corn during the severe drought period forced a reduction in hog production from 1935 to 1938. In the period from 1924 to 1930 there were no sudden changes in the demand for hog products but a gradual increase in consumer incomes. Hence variations in hog prices during this period were largely the result of changes in supplies. From 1926 to 1933 supplies of hogs fluctuated less than in any period of similar length since 1900, as shown by Fig. 58. From 1926 to 1930 demand was fairly constant, producing a period of unusual stability in hog prices. From 1930 to 1933 there was little change in slaughter supplies, but hog prices during this period declined to the lowest level in fifty years. During this period changes in domestic and foreign demand and in the general price level were primarily responsible for the decline in hog prices. As hog production after 1937 recovered from the low levels of the drought period, and as there was little improvement in demand, hog prices were adversely affected by the increased supplies and dropped sharply in 1939 and 1940. Then as the effects of the war became evident in sharply advancing incomes and increasing exports, hog prices advanced sharply and steadily until halted in 1943 by price ceilings. With the record pig crop in 1943, supplies of hogs in 1944 were large enough to more than offset increased demand and incomes, and prices dropped below ceilings. Since 1945 hog prices have reflected both increased demand and decreased supplies. Ceiling prices permitted some changes. After ceilings were removed the short supplies and increased demand worked together to push prices up to extreme limits.

SEASONAL VARIATIONS IN HOG PRICES

During most hog-marketing years hog prices are lowest during the winter months and highest in the late spring and late summer. These seasonal changes in price are a result of seasonal fluctuations in supplies of slaughter hogs, with such supplies being largest during the winter months and smallest during August and September. This seasonal fluctuation in hog supplies is caused largely by the fact that farrowings are concentrated in a relatively few months. Over 60 per cent of the annual pig crop comes from pigs farrowed in the spring season (December 1 to June 1), and over 60 per cent of the spring farrowings are in March and April. Around two-thirds of the fall farrowings are in the three months of August to October, with September the month of largest farrowing.

The length of the feeding period for hogs varies considerably among regions as well as among producers in the same region. In the north-central states and the northwest Corn Belt, especially in Nebraska, South Dakota, and northwestern Iowa, hogs are fed longest and to heaviest weights. Hogs are marketed at lightest weights and fed the shortest in the eastern and southern parts of the eastern Corn Belt. In general hogs are fed longest in areas where the system of one litter per year prevails, and the shortest where the two-crop system is largely followed. As with farrowings, so with marketings; there is a marked tendency for concentration in two limited periods of the year. Although the marketing period for spring pigs extends from September through April, most of them are marketed in the six months from October through March, with a heavy concentration in December and January. Fall pigs are marketed from March to September of the following year, with a heavy concentration in May and June. In addition to the fall pigs marketed in the summer months, large numbers of sows are also marketed. These are known to the trade as packing sows or just "packers." These

are practically all sows that farrowed pigs in the spring season, and they are marketed very largely from the so-called one-crop areas where the number of fall pigs produced is relatively small.

The hog-marketing year is commonly considered as beginning October 1, since fall pigs of the previous year are mostly marketed by the end of September and volume movement of the current year's spring crop begins in the latter part of September. In general the hogs marketed in any hog-marketing year include the spring pigs and fall pigs of the year in which the marketing year begins. Hogs marketed in the 1946–1947 hog-marketing year include pigs born in the spring and fall of 1946.

As marketings of spring-crop pigs increase from October to January, the usual and generally anticipated seasonal decline in prices occurs. As supplies tend to drop off in February and March, prices usually make a seasonal advance. As the volume movement of fall pigs increases in late April and May, prices usually decline until after the heaviest movement is over, usually in June. Supplies of butcher hogs are the lightest of the year during the summer months, and prices for butcher hogs usually reach the highest level of the marketing year during these months. Butcher hogs are young, well-finished animals weighing from 225 to 400 pounds. Prices of sows marketed during the summer months are usually substantially lower than prices of butcher hogs. Thus during the summer there is usually a wide spread between the average price of all hogs and the average price of butcher hogs. The normal month-to-month variations in hog prices and in supplies of hogs for slaughter are shown in Fig. 61. If the average prices of butcher hogs were listed instead of the average prices of all hogs, the prices from October to June would not be greatly changed but the prices in July, August, and September would be considerably higher.

The range in prices of hogs within any one marketing year is usually relatively less than the range in the supplies of hogs

in that year. This situation arises from the fact that in the winter, when slaughter supplies of hogs are largest, packers accumulate large quantities of hog products in storage. Thus the quantity of products entering domestic consumption and export channels during these months is smaller than the pro-

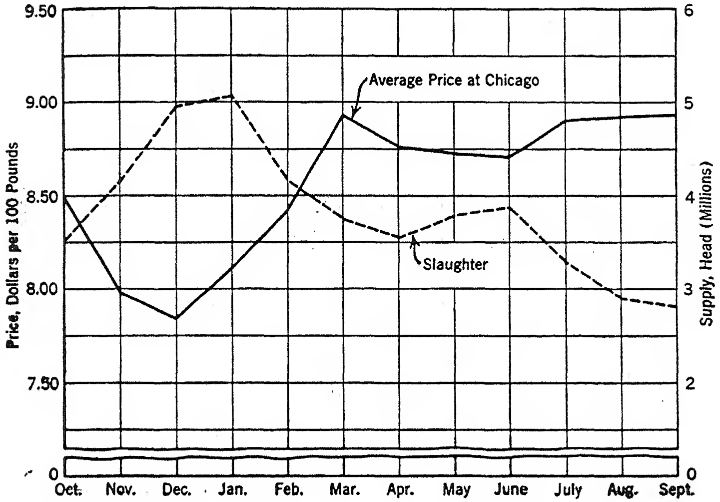

FIG. 61. The prices of hogs tend to be relatively low in the months when supplies are relatively large and to reach the highest level of the year in months when supplies are smallest.

duction of products from the hogs slaughtered. These storage supplies are largely held until the summer months when slaughter is the smallest, and then they are moved into consumption. During the summer months the quantity of hog products consumed and exported exceeds the quantity produced from hogs slaughtered during those months. This holding of hog products from winter to summer has the effect of raising hog prices in the winter and holding down prices in the summer from what they would be if hog products had to go into consumption at the time the hogs are slaughtered. Although this

relationship of seasonal prices and seasonal supplies is normal, some years depart materially from it. This departure may be due either to sudden changes in demand during the season, as during a rapidly developing depression, or to an abnormal distribution of supplies arising from marked differences in the relative changes in the size of the spring and fall pig crops of the same year.

REGIONAL VARIATIONS IN HOG PRICES

Figure 54 of Chapter XXIV showed the variations of corn prices over the United States. Figure 62 shows the variations in hog prices. It is interesting to note that the area of low prices for corn is also the area of low prices for hogs. This area is located largely in the north-central states west of the Missouri River. As with corn, the prices of hogs tend to increase east and west of this area with the highest levels of prices being found in the two coastal regions. But, contrary to changes in corn prices, the prices of hogs do not increase to the south and especially to the southeast. As shown in Fig. 62 the prices of hogs in the Gulf states are about as low as they are in the low-price area of the northern plains states. Since these are deficient hog-producing states in the sense that they depend on supplies of pork products from the Corn Belt to supplement local production, it is obvious that this situation does not arise from supply conditions. The principal cause lies in the differences in the type and quality of the hogs raised in the south. Southern hogs are largely marketed at light weights and go into consumption as fresh pork. Also, as a result of the kinds of feed used, such as peanuts and wild nuts, most of these hogs produce so-called "soft" or "oily" pork. Many of these hogs are sadly lacking in conformation and finish. For these reasons a large part of the hogs in these states sell at low prices relative to the prices of well-finished and well-bred hogs in other areas.

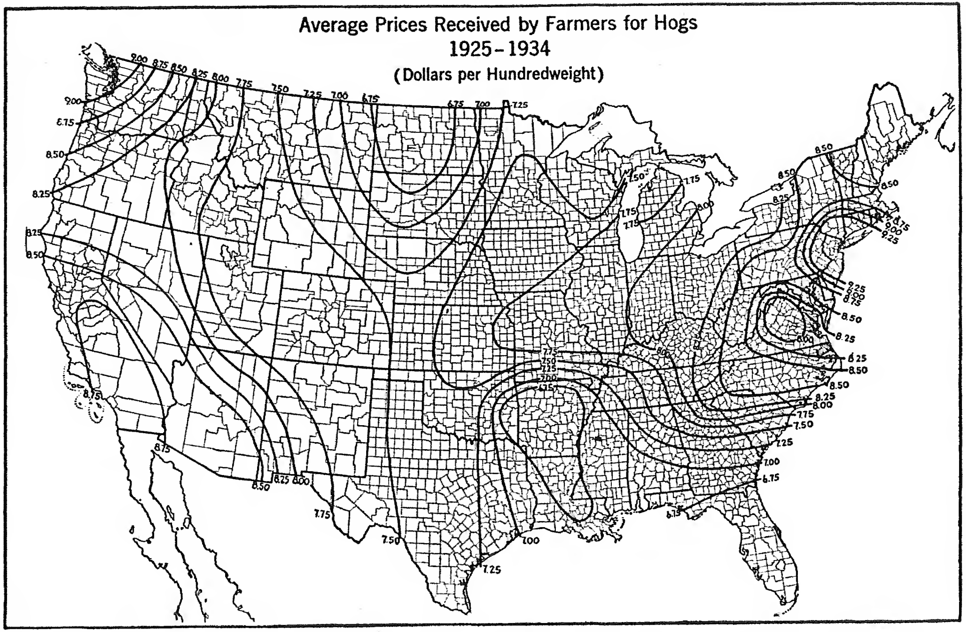

FIG. 62. The area in which lowest prices are received by farmers for hogs is much the same as that in which farm prices of corn are lowest—the northwestern part of the west and north-central states. Prices increase progressively in all directions from this area except to the south and southeast in the Gulf and South Atlantic states. Undesirable type and poor quality of many hogs in these states hold prices down.

RELATION OF EXPORTS TO THE HOG SITUATION

As hog production and large-scale commercial slaughter of hogs expanded after the close of the Civil War a substantial part of the products from this slaughter found a foreign outlet. Exports of hog products increased steadily until about

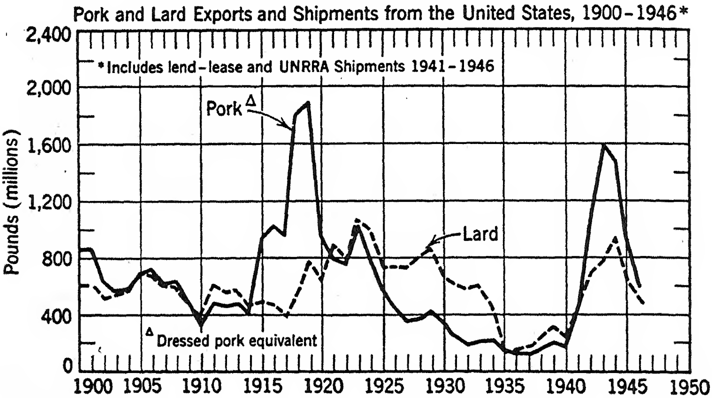

FIG. 63. Exports of hog products declined gradually from 1900 to 1915 and increased markedly during World War I. They then declined rapidly to very low levels in the drought years but expanded sharply during World War II.

the close of the last century. During this period the population in European countries was increasing and becoming more industrialized with a resulting strong demand for cheap food from outside areas. At the same time the western expansion of agriculture in this country made possible a marked increase in hog production. Thus the increase in exports of hog products during this period was a natural outgrowth of demand conditions in Europe and supply conditions in the United States.

After 1900 (see Fig. 63) and until the beginning of World War I exports of hog products tended to decline. Among the reasons for this decline were the failure of hog produc-

tion to keep up with the continued rapid increase in population, mostly urban and industrialized, in the United States; the stabilization of the industrial population in Europe; and the expansion of agriculture in Europe, prompted partly by restrictions on imports. The downward trend was checked by World War I, and exports of hog products increased as a result of the war demand from Europe. Exports of pork reached an all-time record high in 1919. From the close of the war until about 1924, exports, especially of lard, remained on a high but declining level encouraged by the heavy production of hogs in this country and supported by American loans to Germany. It was not until 1930 that total exports again dropped to the level of the immediate prewar years. From 1930 to 1940, as hog production was reduced to a low volume in the drought years, exports almost disappeared. In some of these years there were substantial imports into the United States, which in 1937 exceeded exports.

In 1939 the World War II demand for hog products began to develop. After the United States entered the war in 1941, exports increased greatly, reaching a peak in 1945. Most of these exports were made under lend-lease and were financed by the government of the United States. The record production of hogs in this country in the years 1942–1945 made these exports possible and still left record or near record per capita supplies for the United States civilians after the needs of the armed forces had been met. As indicated in Fig. 63, the export demand for pork in World War II, as in World War I, increased more than for lard, and in the period 1942–1946 exports of pork exceeded those of lard. Beginning in 1945, however, exports of pork dropped off much faster than those of lard. In 1947 exports of lard exceeded those of pork, and this situation is fairly certain to continue.

The most important factor responsible for the decline in exports in the 1920–1932 period was the marked increase in the production of hogs in Europe. From 1935 to 1939, however, the important factor was the sharply reduced production of

hogs in the United States. The inverse relationship between exports of hog products from this country and hog slaughter in Germany and Denmark during the interwar period is clearly indicated in Fig. 64. Since Denmark was an important source of cured pork imports into Great Britain, the increase in

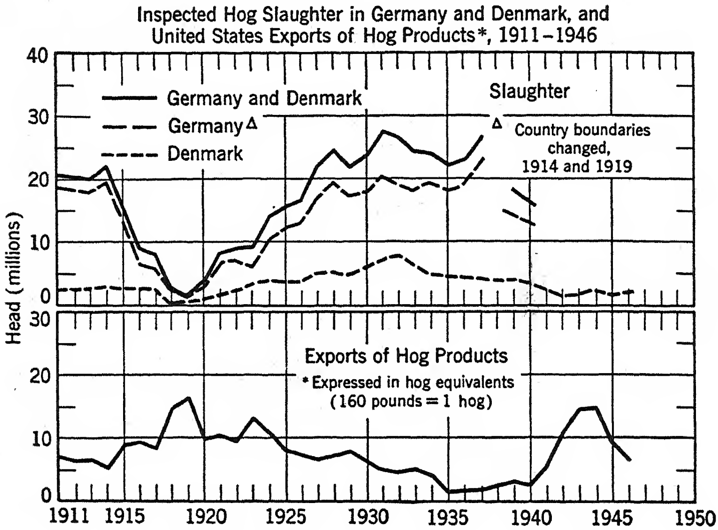

Fig. 64. Hog slaughter in Germany and Denmark expanded rapidly after World War I, and products from this slaughter tended to replace United States hog products in European importing countries.

Danish hog slaughter resulted in larger exports of Danish bacon to the British market and smaller imports of pork from the United States. The increase of hog slaughter in Germany reduced the dependence of that country on lard from foreign markets and, as a result, exports of lard from the United States decreased. After 1930 hog production tended to increase not only in Germany and Denmark but also in Poland, Holland, and Hungary, and a government-sponsored program for increasing hog production in England was inaugurated. During the early 1930's several foreign countries, in order to

aid hog production in their own countries, placed rather severe restrictions on the imports of hog products from the United States. In Great Britain these restrictions took the form of quota limitations on imports from non-Empire countries, and in Germany near-prohibitive tariffs and import-export trade controls were imposed.

The very serious financial situation which developed in Great Britain after the close of World War II and which promises to continue for a considerable number of years will restrict greatly the British market for hog products from the United States. Since this has always been the principal foreign market for pork from this country, the future of the export pork market in the postwar years is far from bright. The rehabilitation of Germany has been and will probably continue to be so slow that it will be a good many years before the German people will be able to buy any great quantity of hog products from other countries and especially from this country.

CORN AND HOG SURPLUS PROBLEM

As a result of the sharp drop in the prices of farm products after the close of World War I and the agricultural depression extending over the first half of the decade of the 1920's, surplus production emerged as problem number one of American agriculture. Many proposals for governmental action to help solve this problem and to improve the situation of agriculture were forthcoming. This agitation finally resulted in two concrete legislative actions in 1929. One was the increasing of the tariffs on farm products. The other was the establishment of the Federal Farm Board which was authorized to support the prices of farm products that were in surplus supply by buying up and holding off the market and to improve the marketing of agricultural products by actively promoting the establishment of cooperative marketing agencies. Neither of these actions involved any governmental control of production nor any limitations on the actions of individual farmers.

As the great depression developed during the early 1930's the futility of these actions to stem the precipitous drop in prices of farm products was clearly evident. Demands for other and more drastic action grew more insistent as the economic and financial conditions of agriculture became more critical. In 1933 the first legislation providing for direct governmental control of production and marketing was passed. Thus the years from the end of World War I to the end of World War II, during which the situation of agriculture was a constant political problem, can be separated into two periods—a free economy up to 1933 and a controlled economy from 1933 to 1946.

Out of the first legislation for production control came the corn-hog program of the Agricultural Adjustment Agency (AAA). The first action under this program was the purchase and slaughter for consumption of some 6 million pigs in the summer of 1933. This was done to reduce the supply of marketable hogs from the pig crop of 1933, the largest on record up to that time. At the same time a corn-loan program to include corn sealed in farm cribs was established. From that time up until late 1946 governmental controls or actions affecting corn or hogs or both have been in operation. The relationship that prevailed prior to 1933 between supplies and prices of corn and hogs and the interrelationships between these two have changed. Governmental policies and actions have tended more and more to modify the old relationships that had developed under the old economy.

The underlying theory of these governmental controls was to increase or hold up the prices of farm products by reducing the acreage and production and hence the supplies. With corn this took the form of acreage allotments in the so-called surplus corn counties, which included all the leading Corn Belt corn- and hog-producing counties. But a new factor was coming into the corn situation; the rapidly expanding use of hybrid seed corn and the resulting pronounced increased yields per acre were more and more offsetting the controlled reduction of corn acreage. The effects of this were more or less concealed

during the drought years, and overall yields in the Corn Belt were held down by the low yields in the drought areas. But by 1938 and 1939 rapidly expanding use of hybrid seed and more favorable weather were resulting more and more in higher yields. (See Fig. 4.) The acreage of corn harvested in the north central states declined almost continuously from the all-time peak of 69.7 million acres in 1932 to 48.8 million acres in 1940, a drop of 30 per cent. Production, which set an all-time record with 2.2 billion bushels in 1932, dropped only 22 per cent. In 1942 a new record of production of 2.4 billion bushels was made from 52.0 million acres, and this was followed in 1946 with 2.6 billion bushels from 58.9 million acres.

Between World War I and the depression years of the early 1930's, the steady decline in the number of horses and mules on farms was reducing the quantities of corn and other feed grains needed to maintain work stock, and making more available for other livestock, including hogs. From 1920 to 1932 the number of horses and mules on farms dropped from 25.7 million to 17.8 million head. According to estimates of the United States Department of Agriculture, the quantity of corn fed to horses and mules dropped from 18.0 million tons in 1920 to 10.3 tons in 1932, a decrease of nearly 7 million tons equivalent to about 250 million bushels.

This decline in the number of work stock has continued steadily from 1932 to the present and at an accelerated rate the last few years. On January 1, 1947, there were only 10 million head of horses and mules left on farms. The quantity of corn fed in 1946 was probably not over 3.5 million tons. Thus there has been a further decline of about 7 million tons in the use of corn by work stock between 1932 and 1946. In the last twenty-five years the rapid disappearance of horses and mules from farms has reduced annual corn feeding to work stock by about ½ billion bushels, with material but less drastic decreases in other feed grains. Hay fed to work animals is estimated to have declined from 31.5 million tons in 1920 to 15 million tons in 1946, a decrease of 55 per cent, and

there was doubtless a somewhat similar decrease in pasture and range feed. In 1920 nearly one-third of the hay produced was fed to work stock on farms and an additional 3 or 4 per cent to horses and mules not on farms. In 1946 only about 15 per cent was fed to farm work stock and less than 1 per cent to non-farm horses and mules. This reduction was especially great in the Corn Belt.

The policy of reduced acreage and restricted production which dominated governmental control from 1933 to 1940 was changed as the result of conditions engendered by World War II. All-out production of farm products, especially of food and feeds, to meet the growing war demand became the watchword. As a protection against the possible adverse effect of such production on prices, a program of price supports was established by statute. These were embodied in the Steagall Amendment to the War Powers Act and provided that prices of so-called basic commodities and of other commodities for which increased production was asked should be supported at 90 per cent of parity for two years after January 1 following the official end of the war. These supports will thus continue through 1948. Both corn and hogs are included on the list of commodities whose prices will be supported.

Parity defined. The prices paid for farm products during the period 1910–1914 is called the base period for calculation of parity. When corn prices are at parity the money received for a bushel of corn will buy as much of non-farm commodities as in 1910–1914. There has been some change to include items not mentioned in the earlier calculation of parity. Taxes and interest are now included in calculation of parity price for food and fiber.

The ten-year average just previous to the crop-producing year is the designated base for calculating parity after 1950. When corn prices are at parity the money received for a bushel of corn will buy as much of non-farm commodities as in the immediate ten previous years. The ten-year base probably means that the parity price of corn will be somewhat

lower in relation to other commodities than the price calculated on the 1910–1914 base. This lowering is to be done gradually. The reduction in price cannot be more than 5 per cent change in any one year. The price change therefore will be gradual as a result of this provision.

"Total supply" as used by the law is the indicated production plus carry-over and plus estimated imports. The "normal supply" for corn in any given year is the estimated domestic consumption during the preceding marketing year, estimated exports for the new year plus an allowance for carry-over (7 per cent of total consumption and exports).

Since decisions are left to the discretion of the Secretary of Agriculture, support of the price of corn by the U. S. Department of Agriculture is to be somewhere between 90 per cent of parity as an upper limit for a short corn supply and 60 per cent as minimum low for an abundant supply. Congress may change the legal definition of parity.

As corn production increased after 1936 there was a lag in the increased production of hogs, and corn prices declined as a result of the restricted demand. The governmental corn loan program expanded rapidly. During the years 1938–1940 there was a continuous increase in the quantity of corn owned by or under loan to the Commodity Credit Corporation. The carry-over of corn into the new crop years beginning October 1 increased correspondingly and by October 1, 1940, reached a record total of 688 million bushels. This was nearly four times as large as a normal carry-over in the precontrol years. Government stocks of wheat also expanded greatly during this period. (See pages 271–272.)

Hog production increased after 1937, following the short production of the severe drought period from 1934 to 1936, and prices declined from the high levels of the drought period. But hog prices dropped much less relatively than did prices of corn, even though corn prices were held up by the loan program, and the hog-corn ratio went up sharply. Hog production made a near-record percentage increase in 1939, hog prices

dropped to very low levels in 1939 and 1940, and the hog-corn ratio fell far below average. Farrowings were reduced in 1940 and would have been further reduced in 1941 except for the actions taken to encourage farmers to maintain production.

During the early years of World War II, government policy was directed to increasing the production of animal products, meat, milk, and eggs. As a part of this program feed grain prices were kept down by the use of the large government stocks, whereas animal products prices advanced. When ceiling prices were established in 1943 this price relationship between feed grains and livestock products was more or less frozen into the ceilings. Encouraged by high hog prices, a high hog-corn ratio, abundant feed supplies, and guaranteed support of prices, hog producers increased production for three years in succession, 1941, 1942, and 1943. The pig crop of 1943 reached 121.8 million head, nearly twice as large as the average of the drought years. Dairy cows and milk production, laying flocks and egg production, chickens and turkeys raised, all made marked increases to establish new production records. By the middle of 1944 accumulated stocks of feed grains and wheat were used up, and feed ratios became less and less favorable as growing shortages and "black markets" forced advances in feed grain ceilings. Hog prices dropped below ceilings and there was a precipitous drop in the size of the 1944 pig crop. But as hog marketings declined in 1945, prices again advanced to ceiling levels and continued there until price control was ended. They then jumped up sharply as prices of hog products advanced to their usual relationship to incomes of consumers.

HOG OUTLOOK FOR THE POSTWAR YEARS

With the ending of rationing and price control in the fall of 1946 the prices of hogs and corn advanced to levels determined by the operation of the various forces that influence prices in a free market. For the first time since 1933 there

were no governmental controls which tended to affect prices. The fact that the government controlled export allocations and was doing most of the buying for export and for foreign relief did give government actions an influence in the market. However, purchases were made within the usual market routine. Also, government controls were in the background in the provisions of the Steagall Amendment for supporting prices for two years in the postwar period. Prices of both corn and hogs were to be supported at 90 per cent of parity. If supports for both should be needed and effectively carried out, the resulting hog-corn price ratio would be equivalent to the ratio derived from the 1909–1914 prices of hogs and of corn, which is about 11.3. If the parity ratio, the index of prices paid by farmers, interest, and taxes, continues at about the level of the first half of 1947 the seasonal average price of hogs would be about $15.00 a hundred pounds and of corn $1.35 a bushel. However, the ratio could be either above or below 11.3 if the prices of one or the other, or of neither, did not drop to the support level. Conditions in the late summer of 1947 indicated that neither would drop to the support level during the period when supports were in effect, through 1948, and that the ratio during that time would be below average as a result of the short crop of corn in 1947.

The kind of agricultural economy that may evolve after 1948, whether of the prewar type of limited production to support prices or of the war type of full production and price supports, will materially affect the trend of hog production in the future. One thing is certain. Corn production in the next ten years will average materially larger than the average of the decade 1921–1930 and may well average over 3 billion bushels a year, barring a succession of drought years such as occurred in the 1930's. The number of work stock will probably continue to decline, thus making additional quantities of corn available for other livestock. On the basis of potential corn supplies hog production could be at a level that would

furnish a per capita supply of pork and lard considerably above the prewar and predrought average unless a foreign outlet for large quantities of hog products, especially of lard, can be developed.

If the volume of industrial production and consumer incomes are maintained at levels about equal to the average of the 1944–1947 period, it is probable that a supply of pork giving an annual per capita consumption equal to the five-year (1940–1944) average civilian per capita consumption of about 70 pounds would bring prices high enough to hold hog prices above the support levels. If hog production reaches a volume that exceeds the per capita demand and no foreign outlet can be found for the excess, hog prices may drop rather sharply.

World economic and social changes have in the past modified the policy of the United States Government. It is therefore possible to assume that world changes can influence the government policy toward agricultural production. The Food and Agriculture Organization of the United Nations urges that the people of the world be fed. At the same time the continued and increased productivity of the agricultural soil is to be maintained or, if possible, increased. Government support of prices for hogs has in the past helped stimulate a uniform movement of hogs to market one year following another. A very potent influence in this uniform production of hogs has been the corn loan program as discussed in Chapter XXI, page 271. Both have found favor with producers of corn and hogs.

The periods of higher and lower ratios between corn and hogs may be disturbed by violent sudden changes in price levels as was true early in 1948. These violent fluctuations were not caused by a government agricultural policy directed toward production areas as such. Rather, they are a part of war aftermath where credit was easy and money less valuable and more plentiful. These plus an increased buying of grain for export certainly influenced irregular and violent

changes in the corn-hog ratio. There is hope that the continuance of the wise government policies initiated in the 1930's toward corn and hog production will help supply the world food demand as anticipated by the Food and Agriculture Organization of the United Nations.

CHAPTER XXVI

PROBLEMS AND COMMUNITY STUDIES

This chapter is especially for high-school and college students who want to know how corn is being grown in their home communities and to discover methods of improvement. First, some of the simple arithmetical problems of corn growing are considered, and after that community studies of corn are suggested.

PROBLEMS OF CORN GROWING

1. Determine the number of hills in an acre of corn when the hills are 3 feet 6 inches apart each way; when the hills are 3 feet 4 inches by 3 feet 6 inches apart; when the hills are 3 feet 4 inches apart each way; when the hills are 3 feet apart each way.

Suggestions: There are 43,560 square feet in an acre. Each hill occupies 9 square feet when the hills are 3 feet apart each way.

2. If three kernels to the hill ordinarily give an average of 2.6 stalks to the hill, about how many stalks will there be on an acre with hills 3 feet 6 inches apart planted at the three-kernel rate? How many stalks to the acre will three-kernel plantings give with the other distances suggested under Problem 1? If the corn is power-dropped in rows 40 inches apart, how many kernels are planted to the acre if two kernels are dropped every 21 inches? If the corn is drilled in rows 40 inches apart, how many kernels are planted to the acre if one kernel is dropped every 10 inches in the row?

3. With 10,000 stalks per acre, how many ounces of ear corn must the average plant produce to make a yield of 30 bushels per acre? of 40 bushels? of 50 bushels? of 70 bushels? of 100 bushels? Answer these same questions for stands of 9000, 8000, 7000, and 6000 stalks per acre.

4. If a full-grown corn plant evaporates 5 pounds of water daily during midsummer, how many tons of water will an acre of 9000 corn plants evaporate in the 30-day period from July 10 to August 9?

5. If 110 tons of water make an acre-inch, about how many inches of water are represented by the monthly evaporation calculated in Problem 4?

6. If a bushel of soft corn on the ear weighs 90 pounds and is 25 per cent cob and 30 per cent water, how many pounds of dry feeding matter will there be in the grain of the 90 pounds? If a bushel of No. 2 corn on the ear weighs 70 pounds and is 20 per cent cob and 16 per cent water, how many pounds of dry feeding matter will there be in the shelled corn? If the 90 pounds of soft corn can be bought for 70 cents a bushel and the 70 pounds of No. 2 corn can be bought for 90 cents a bushel, which is the better buy for winter feeding, assuming the soft corn can be stored without spoiling?

7. How many miles will a man travel in cultivating an acre of corn with the rows 3 feet 6 inches apart if he uses a one-row cultivator? If he cultivates 7 acres in an 8-hour day, what is his rate of speed per hour? If he cultivates 12 acres with a two-row cultivator in an 8-hour day, what is his rate of speed per hour? How many acres will he cultivate in an 8-hour day with a four-row cultivator at 4 miles an hour, on corn that is planted in rows 3 feet 4 inches apart?

8. Allowing 40 pounds to the cubic foot of settled silage, how many tons are there in 30 feet of settled silage in a 16-foot silo? Allowing 43 pounds to the bottom third of settled silage, how many tons are there in the bottom 9 feet of a 14-foot silo?

STUDYING CORN IN A COMMUNITY

In order to form practical judgment on corn, it is necessary to find out just how the farmers are growing corn in a community. Different farmers grow corn in different ways. In order to develop a direct contact between the student and the corn as it is actually grown, it is suggested that three different blanks should be filled out. To fill out the first blank the student should interview his father or some corn farmer in the neighborhood.

BLANK 1

COLLECTING CORN INFORMATION FROM THE FARMER REGARDING A PARTICULAR CORN FIELD

What is the soil type?
What crop was grown on this field last year?
  Two years ago?
  Three years ago?
  Four years ago?
  Five years ago?
How much manure, lime, or other fertilizer was spread on this field last year?
  Two years ago?
  Three years ago?
  Four years ago?
  Five years ago?
Taking both soil type and soil treatment into account, what percentage is this field above or below average?
What hybrid corn was planted on this field?
Is the corn a big-eared, medium-eared, or small-eared type?
Ask the farmer for three ears illustrating the type of seed corn he likes.
Was the seed treated with commercial dust?
When was the field planted?
How far apart each way were the hills spaced?
How many times was the corn cultivated?
What is the farmer's estimate of the yield per acre?
What was the rainfall and temperature like during the summer?
Any particular items of interest offered by the farmer.

Too few farmers and farmers' boys give corn an intensive study in the field in September and October. The most im-

portant thing to be learned is whether the stand was too thick or too thin to utilize fully the soil fertility, the rainfall, and the type of corn. The information as to soil fertility, rainfall, type of corn, etc., is found in the answers to the questions of Blank 1. Blank 2 is based on the idea of using the corn field as the laboratory. The problem is to go into the field and count the stalks in representative hills in different parts of the field and then finally make an estimate of the total number of stalks in an acre. After all the information is weighed, a conclusion should be reached as to whether the stand in the particular field was too thick or too thin in order to obtain the maximum yield of sound corn.

BLANK 2

Collecting Corn Information about a Particular Field by Field Study in September and October

How many stalks are there in seventy representative hills?
- How many smutted stalks?
- How many two-eared stalks?
- How many barren stalks?
- How many corn borers?

On the basis of the above sample how many stalks are there per acre?
- How many broken stalks?
- How many leaning stalks?
- How many smutted stalks?
- How many two-eared stalks?
- How many barren stalks?

How many pounds does the ear corn from fifty hills weigh?

How many pounds should be allowed to the bushel of ear corn at the time this weight is taken?

Allowing 70, 80, 90, or whatever number of pounds is about right, what is the indicated yield per acre from the fifty-hill sample?

The last part of Blank 2 contains the question, "How many pounds does the ear corn from fifty hills weigh?" When corn is thoroughly matured 70 pounds of ear corn are required to make a bushel. When the hills are 3 feet 6 inches apart each way, the number of pounds of ear corn from fifty representative hills gives a fairly accurate figure of the number of bushels

of yield per acre. In other words, if the ear corn from fifty hills weighs 63 pounds then it would be assumed that the field was yielding around 63 bushels to the acre. An interesting school project is to take a sample from a field of corn in late September or early October, weigh it immediately after it is taken from the field, and hang it up in a dry room. Weigh it three weeks later after the water has dried out and then calculate the percentage of shrinkage. See Table 20.

BLANK 3

Collecting Corn Information from 100 Pounds of Average Crib-Run Corn from a Specified Field

How many ears are there in 100 pounds of crib-run corn?
What does the average ear weigh in ounces?
  How many ears weigh less than 5 ounces?
  How many ears weigh from 5 to 8 ounces?
  How many ears weigh over 8 ounces?
What is the shelling percentage of the sample?
What is the moisture percentage of the sample?
What is the test weight per bushel of the shelled corn?
What is the commercial grade and probable Chicago price per bushel of shelled corn?
How many kernels are there in an ounce of the shelled corn?
Out of 100 representative kernels taken from the sheller, how many are bright and shiny and how many are dull and starchy?
How many rows of kernels are on the average ear of corn?
Is there a difference in the number of rows on the ears where the kernels run parallel to the cob as compared to those that run spiral around the cob?

The questions in Blank 3 are best answered by the students during the winter months. The idea is to study crib-run corn as it exists in the average farmer's crib. One hundred pounds of average corn should be taken out of the crib with a scoop shovel in such a way that there is an absolutely fair sample, and this corn should be brought into the schoolhouse or some other place where the questions in Blank 3 can be answered. If, as a result of Blank 1, the student is able to have on hand three ears illustrating the type of seed corn the farmer likes to

plant, he will find it interesting to compare these with the field run. In the central part of the Corn Belt, the big ears will average about a pound in weight, whereas the average ear as it comes from the field will average only about a half a pound. The most important thing is to shell the corn and give it a commercial grade based on the moisture test and the test weight per bushel. Special apparatus is needed for determining both moisture and test weight per bushel. If such apparatus is not available in the school it may be possible to have these points bearing on the government grade determined by sending a pound sample to some elevator or Board of Trade where there is the necessary equipment for making such tests. Some tests may be made free of charge but others may cost as much as a dollar.

The most interesting information will come after the different students have filled out these blanks and it is possible to tabulate side by side the information from at least half a dozen different corn fields. Do high-yielding fields owe their yield to a good stand or to soil fertility? To what extent do the high-yielding fields have the largest ears? Does early planting influence the commercial grade of the corn? What is the influence of soil fertility on the commercial grade of the corn? In studying all of these things, it will be found occasionally that there is no theory which adequately explains the results. Perhaps the students who fill out blanks of this sort will discover things which none of the professors and experimenters have ever known before.

IMPROVING COMMUNITY PRACTICES

The teacher of vocational agriculture will find it worth while to stimulate community corn enterprises. Hitherto the easiest thing to do has been to put on a corn show. Corn shows are all right as far as they go and they stir up considerable interest.

A new kind of corn show which vocational teachers can work out for themselves to fit their local situation is based on the idea of crib-run corn somewhat as presented in Blank 3. The competing corn is brought in on the ear just as it comes from the crib without any selection and then is shelled and finally judged on a shelled basis. The standard of judgment is the commercial grade and what the terminal market would pay for it. In such a corn show, the shelling percentage, moisture determination, and test weight per bushel are ideally done by the students in the high school. An exhibit might be held and the percentage of moisture, test weight per bushel, shelling percentage, etc., placed on each sample. It is interesting if five or six ears which were not shelled are exhibited along with these samples. These ears have nothing to do with the determination of the awards, of course, but merely give an idea of how the ear corn looked on the cob.

Finally a corn meeting can be held in the late winter at which the results of the student study as obtained from Blanks 1, 2, and 3 can be set forth for the benefit of the practical farmer. Better yet, practical farmers can suggest ways in which the blanks can be improved to bring out ideas which the students have not discovered. Discussions can be held as to the proper number of stalks per acre to fit soils of different fertility in different seasons when planted with different types of corn.

The vocational agricultural teacher may foster a strip yield test or a ten-acre yield test on some farms. Information about details may be obtained from state experiment stations.

A multitude of community corn projects will suggest themselves to the vocational agricultural teacher. In time he will discover certain things which are hidden today even from our most advanced research workers in corn.

CHAPTER XXVII

CORN PRODUCTS AND THEIR USES

Furnished here is a list of commercial products that are in part or entirely made up from corn. In no sense is this to be considered a finished list. The ingenuity of the manufacturers who use corn as a raw material is continually adding to this list. For the benefit of those that think corn is only animal food, this list should be very enlightening.

Human Use

(Mostly food)

Corn husks
  Tamales (as a wrapper)
Corn grain
  Canned corn (succotash, chowder, scallop, fritters, etc.)
  Ear corn (table use as a vegetable)
  Parched corn
  Popcorn and popcorn confections
Corn meal, corn flour, and corn grits
  Baby foods
  Bakery products (bread, rolls, cakes, cookies, etc.)
  Baking powder
  Beverages, brewed
  Biscuits and crackers
  Bread, muffins, puffs, cake (johnnycake)
  Bread improvers
  Confectionery
  Corn flakes and other breakfast foods
  Desserts (puddings, custards, etc.)
  Flours, prepared (including prepared mixes)
  Food-thickening agent (cream soups, canned corn, gravies, pies, chop suey, chili con carne, etc.)
  Fritters

Corn meal, corn flour, and corn grits (*Continued*)
- Griddle cakes
- Hoecake (pone, tortilla)
- Hominy, boiled (samp)
- Malt sirup
- Mush (polenta)
- Pharmaceuticals (binder and extender in tablets, etc.)
- Pie filling (chocolate, lemon, etc.)
- Porridge
- Puddings and custards, etc.
- Salad dressing
- Sausage
- Scrapple
- Tamales
- Waffles
- Yeast

Cornstarch
- Bakery products (bread, rolls, cakes, pies, etc.)
- Baking powder
- Beans, baked
- Beverages, brewed
- Biscuits, crackers, and cookies
- Canned corn, soups, etc.
- Chewing gum
- Cones, ice cream
- Confectionery
- Cosmetics (dusting face and talcum powders, tooth paste, foot powders, etc.)
- Desserts (puddings, custards, etc.)
- Fish food
- Flours, prepared (including prepared mixes)
- Food-thickening agent (cream soups, canned corn, gravies, pies, chop suey, chili con carne, etc.)
- Malt sirup
- Mustard, prepared
- Pharmaceuticals (binder and extender in tablets, nutrient medium for penicillin and for antitoxin for gas gangrene, etc.)
- Pie filling (chocolate, lemon, etc.)
- Puddings and custards
- Salad dressing
- Salt, table
- Sausage and other ground meat products
- Stabilizing agent

Cornstarch (*Continued*)
- Sugar, powdered
- Yeast

Corn Sirup (liquid or dried)
- Bakery products (bread, rolls, cakes, cookies, pies, etc.)
- Beverages, brewed
- Beverages, nonalcoholic, carbonated
- Biscuits and crackers
- Cheese
- Chewing gum
- Citrus juice, dried
- Coffee, powdered, soluble
- Condensed milk
- Confectionery
- Extracts and flavors
- Fruit butters and juices
- Humectant
- Ice cream, water ices, and sherbets
- Infant and invalid feeding
- Jams, jellies, marmalades, and preserves
- Licorice
- Marshmallows and related products, icings, etc.
- Mayonnaise
- Meat products
- Mincemeat
- Pharmaceuticals (including tooth paste)
- Pickles and relishes
- Rations, emergency
- Rice and coffee polish
- Sauces
- Sausages
- Soup, dehydrated
- Sirups (table, chocolate, cocoa, fruit, cough, medicinal, soda fountain, cordials, etc.)
- Tobacco
- Vegetables, dried, compressed (as a binding agent)
- Vinegar

Corn sugar, crude (including pressed sugar)
- Bakery products
- Beverages, brewed
- Caramel color
- Distillation products
- Tobacco

Corn sugar, crude (including pressed sugar) (*Continued*)
  Vinegar
Corn sugar, refined (anhydrous and hydrous dextrose)
  Bakery products (bread, fillings, icing, macaroons, cookies, etc.)
  Beverages, brewed
  Beverages, nonalcoholic, carbonated
  Biscuits and crackers
  Caramel color
  Catsup and tomato sauce
  Cheese and spreads
  Chewing gum
  Chocolate products
  Citrus juice
  Condensed milk and frozen cream
  Confectionery
  Dietetics
  Distillation products
  Flavoring extracts
  Flours, prepared (pancake flour, etc.)
  Food acids (citric, lactic, and gluconic)
  Fruit butters
  Fruit juices
  Fruits and vegetables, canned
  Fruits, candied, glacé
  Frozen food products (cream, eggs, berries, juices, etc.)
  Ice cream, water ices, and sherbets
  Infant and invalid feeding
  Jams, jellies, marmalades, and preserves
  Lactic acid and lactates
  Mayonnaise and salad dressing
  Meat curing and meat products
  Mincemeat
  Pectin
  Pharmaceuticals (intravenous injections, pills, tablets, drugs, etc.)
  Pickles
  Powders (ice cream, prepared, dessert, pudding, gelatin, and summer-drink powders)
  Rations, emergency
  Sauces
  Soup, dehydrated
  Sirups (table, fountain, cough, etc.)
  Tobacco
  Vinegar

Corn sugar, refined (anhydrous and hydrous dextrose) (*Continued*)
  Vitamin C (via sorbitol, sorbose, etc.)
  Wine, brandy, and cordials
Corn oil
  Carrying agent for vitamin products
  Cooking oil (doughnuts, potato chips, and roasting nut industries, and restaurant and institutional trade)
  Margarine and oleomargarine
  Mayonnaise and salad dressing
  Pan greasing
  Shortening
Steepwater (from the wet process of milling)
  Mold, bacteria, and yeast nutrient (penicillin)
Hydrol (corn-sugar molasses)
  Beverages, brewed
  Caramel color
  Distillation products (alcohol, etc.)
  Tobacco
  Vinegar
  Yeast
Lactic acid (edible U.S.P.)
  Bakery products (fruit jellies, etc.)
  Beverages, brewed
  Beverages, nonalcoholic
  Confectionery
  Food preparations (cheese, brine of green olives, pickles, sauerkraut, preserves, jams, jellies, fruit essences, extracts, etc.)
  Fruit pectin
  Ices and sherbets
  Infant feeding
  Mayonnaise
  Medicinals
  Pharmaceuticals, drugs, and medicinal food manufacture
Butyl alcohol
  Antiseptics
  Perfumes
  Synthetic flavors
Acetone
  Candy glazes
  Extraction of essential oils
  Liniments and drugs
  Nail-polish removers
  Perfumes

Acetone (*Continued*)
- Pharmaceuticals

Ethyl alcohol
- Acetic acid
- Antiseptics
- Barber preparations (See "Toilet preparations")
- Beverages
- Candy glazes
- "Canned heat"
- Cosmetics
- Dentrifices
- Deodorants (body and nonbody)
- Disinfectant
- Ether
- Flavoring extracts
- Hair tonics
- Liniments
- Lotions
- Pectin
- Perfumes
- Pharmaceuticals and drugs
- Rubbing compound
- Scientific laboratory work
- Solvent (for food and medicinal preparations, etc.)
- Tobacco
- Toilet preparations (witch hazel, bay rum, hair and scalp preparations, perfume and perfume materials, shampoos, toilet waters, toilet soaps, tooth-cleaning preparations, shaving cream, antiseptics)
- Vinegar
- Vitamin preparation

Livestock Use

Bran or hulls
Cob meal
Corn bran
Corn chop (grain or ear)
Corn feed meal
Corn meal
Corn sugar
Cracked corn
Ensilage
Fodder
Germ cake and meal (dry-milling industry)

Gluten feed
Gluten meal
Grits
Hominy feed
Hydrol (corn-sugar molasses)
Oil cake and oil-cake meat (wet-milling industry)
Riboflavin supplement
Screenings
Shelled corn
Stover

Industrial Use

- Cornstalks (economic possibilities)
  - Paper
  - Wallboard
- Cobs
  - Cork (granulated) substitute
  - Corn-cob meal (for cleaning furs, burnishing metal, removing oil from tin and metal, sweeping compounds, removing carbon from automobile and airplane engines, lightweight ceramics, tile, etc.)
  - Decolorizing solvent
  - Fertilizer
  - Filler for plastics
  - Furfural
  - Heat insulating material
  - Kindling and fuel
  - Pipe bowls
- Stalks and leaves
  - Mattress
  - Nitrocellulose
  - Packing material
  - Paper and paperboard
- Corn meal, corn flour, and grits
  - Adhesives
  - Asbestos
  - Batteries, dry
  - Binder or binding agent
  - Boiler compounds
  - Briquettes
  - Ceramics
  - Chemicals
  - Containers
  - Core binder

Corn meal, corn flour, and grits (*Continued*)
- Cork products
- Doll heads, molded toys, etc.
- Explosives
- Felts
- Gypsum board
- Insulating material (wallboard, etc.)
- Paints (cleaning compounds, cold-water pastes, poster, and sizing)
- Paper and paper products manufacture
- Pastes (wallpaper, etc.)
- Plywood
- Sizing compounds (for textile sizing)
- Soaps and cleaners
- Textiles, warp sizing, finishing, and printing
- Wallboard (gypsum and other)

Cornstarch
- Abrasive paper and cloth
- Adhesives
- Artificial flowers
- Asbestos
- Batteries, dry
- Binder or binding agent
- Bluing
- Boiling compounds
- Briquettes
- Ceramics
- Chemicals (potash, oxalic acid, etc.)
- Clarifying agent
- Coatings on wood, metal, and paper (allyl starch)
- Color carrier in paper printing
- Containers, laminated and corrugated
- Core binder
- Dolls, composition
- Dressings, surgical
- Dyes
- Explosives (dynamite, fireworks, flares, and nitrated starch)
- Insecticides
- Insulating material (wallboard, etc.)
- Laundry (home and commercial)
- Levulinic acid
- Mining (coal, aluminum ore, etc.)
- Oilcloth
- Oil-well drilling

Cornstarch (*Continued*)
- Paints (cleaning compounds, cold-water pastes, poster, and sizing)
- Paper and paper products manufacture
- Pastes (wallpaper, etc.)
- Plastics
- Plywood
- Protective colloids (emulsions)
- Rubber goods
- Rug backing
- Sizing compounds (for textile sizing)
- Soaps and cleaners
- Textiles (warp sizing, finishing, and printing)
- Wallboard (gypsum and other)

Dextrins
- Abrasives
- Adhesives (billboard posting, bookbinding, carton sealing, label pasting, library paste, etc.)
- Asbestos
- Bluing
- Briquettes
- Carpet and rug sizing
- Ceramics
- Cigarette sealing
- Colors
- Containers (laminated, solid fiber, paper bags, tubes, shell cases, etc.)
- Cord polishing
- Core binder
- Crayons (chalk)
- Doll heads, molded toys, etc.
- Dyes
- Dynamite
- Envelopes
- Fireworks
- Flotation agent (molybdenum)
- Gums and glues
- Ink
- Leather
- Linoleum
- Linoleum cement and paste
- Matches (on head and box)
- Mucilage
- Oilcloth
- Oil-well drilling

Dextrins (*Continued*)
- Paints (cold-water, poster, etc.)
- Paper and paper products
- Pastes (wallpaper, poster, etc.)
- Plastics
- Plywood
- Shells, shotgun
- Shoes (counter pastes, polish, etc.)
- Silvering compounds
- Soaps
- Straws
- Textiles, sizing and finishing
- Tubes, spiral and convolute
- Twine
- Wallboard (gypsum and other)
- Window shades and shade cloth

Corn sirup
- Adhesives
- Boiler compounds
- Boot polish
- Dyes and inks
- Explosives
- Foam stabilizer in fire-fighting equipment
- Hot patches for tire repair
- Humectant
- Hydraulic brake fluid
- Leather tanning
- Paper ("glassine" and parchment)
- Plasticizing material
- Rayon (viscose process)
- Textiles, for finishing
- Tobacco

Corn sugar, crude
- Acids, commercial (lactic, acetic, etc.)
- Adhesives
- Chemicals (calcium lactate, sodium lactate, etc.)
- Dyes
- Leather tanning
- Plasticizing agent
- Rayon

Corn sugar, refined
- Acids, commercial (lactic, acetic, etc.)
- Adhesives

Corn sugar, refined (*Continued*)
- Boiler compounds
- Chemicals (calcium lactate, sodium lactate, etc.)
- Dyes
- Electroplating and galvanizing
- Explosives
- Florists' preparations
- Leather tanning and tanning preparations
- Manitol
- Paper manufacture
- Plasticizing and standardizing agent
- Rayon and textiles
- Rubber for manufacture of automobile tires
- Sizing materials
- Sorbitol

Corn oil and free fatty acids
- Ammunition
- Paint and varnish
- Pharmaceuticals
- Rubber substitutes
- Rust preventative (surface coatings)
- Soap
- Soluble oil (leather and tanning use)
- Sulphurized methyl esters of fatty acids as adjuncts to motor oils
- Textiles

Gluten feed and meal, corn oil cake, and corn oil-cake meal
- Amino acids
- Fur cleaner
- Zein and other protein products (used in plastics, films, coatings, paper, shellac substitutes, etc.)

Steep water (from the wet process method of milling)
- Mold, bacterial, and yeast nutrient (penicillin)
- Pharmaceuticals and chemicals

Lactic acid
- Adhesive tape
- Chemicals
- Esters and salts
- Humectants
- Lacquer thinners
- Paint removers
- Plasticizers
- Plastics and resins
- Pyrotechnics

Lactic acid (*Continued*)
- Softeners
- Solvents
- Tanning
- Textiles

Hydrol (corn-sugar molasses)
- Organic acids
- Organic solvents

Butyl alcohol
- Airplane dopes
- Antiseptics
- Brake fluid
- Chemical agents (solvents, detergents, dehydrating agents, defrothers, penetrants, viscosity-reducers, blending agents, etc.)
- Chemical raw material (butyl acetate, butyl acetyl ricinoleate, butyl ether, butyl lactate, butyl stearate, dibutyl phthalate, dibutyl sebacate, dibutyl tartrate, tributyl citrate, tributyl phosphate, butyl borate, butyl oleat, butyl ricinoleate, dibutoxymethane, dibutyl oxalate, etc.)
- Dyestuffs
- Esters
- Explosives
- Finishes, synthetic
- Glass, safety
- Inks, printing
- Lacquers and molded products
- Leather, artificial, patent, and enameled
- Metal cleaners
- Oils, penetrating
- Ore flotation agents
- Paper, coated and stencil
- Photographic film
- Plastics and molded products
- Polishes
- Reagents
- Resins, synthetic
- Rust removers
- Shellac solutions
- Solvent
- Sprays, insect
- Textile products
- Varnishes, spirit and shellac solutions

Acetone
- Acetylene solvent
- Airplane dopes
- Antioxidants
- Cellulose acetate plastics and films
- Chemical agents (for refining, purification, dewaxing, precipitants, dehydrating, etc.)
- Chemical raw material (diacetone, mesityl oxide, iodoform, chloroform, amyl acetate, etc., denaturant for ethyl alcohol, formulas 23-A and 23-H)
- Enzymes
- Explosives
- Extraction medium
- Glass, safety
- Lacquers
- Leather, artificial
- Paint and varnish removers
- Photographic film
- Pyroxylin cements and plastics
- Rayon
- Resins, synthetic
- Solvent for wide variety of organic materials
- Textile specialties

Ethyl alcohol (ethanol)
- Acetaldehyde
- Acetic acid
- Adhesives
- Alcohol, denatured
- Antifreeze
- Biological preparations
- Brake fluids
- Butadiene
- Chemical raw material (including basic medicinal chemicals)
- Cleaning and polishing preparations
- Compasses, thermometers, gages, spirit levels, etc.
- Dyes and intermediates
- Embalming fluids
- Ethers
- Ethylene gas
- Explosives (military and industrial)
- Flotation reagents
- Fuel
- Fulminate of mercury

Ethyl alcohol (ethanol) (*Continued*)
- Glycols
- Insecticides
- Laboratory and experimental uses
- Lacquers
- Leather, artificial
- Oils, cutting
- Nitrocellulose
- Photographic materials
- Plastics
- Poisons, agricultural
- Polishes, shoe and floor
- Rayon
- Resins, synthetic
- Rubber, synthetic
- Shellac
- Soaps
- Solvents (cleaning agent)
- Torpedo (power fuel for propulsion)

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SWEENEY, O. R., "The Commercial Utilization of Corncobs," Iowa State College, Ames, Iowa, Vol. XXIII, No. 15, Bull. 73, 1924.

CHAPTER XXVIII

CORN STATISTICS

Most of the statistics in the following tables are compiled from records of the United States Department of Agriculture. Students who wish to keep these tables up to date should consult future yearbooks and agricultural statistics of the United States Department of Agriculture and the monthly publication *Crops and Markets*.

The farm crops teacher, whether in high school or college, will find it possible to organize a number of research projects on the basis of these tables. For instance, the students can study for themselves the relationship between corn prices and corn yields as well as the relationship of weather records to corn yields. The geographical distribution of corn prices in different kinds of crop years can be investigated. Special attention should be given to the last table in this chapter, dealing with corn quality in different years in Iowa and Ohio. The way in which this is influenced by weather is well worth careful study.

REFERENCES

Yearbook of Agriculture and *Agricultural Statistics* (annuals), U. S. Department of Agriculture.

Biennial Census of Manufacturers, Bureau of Census, U. S. Department of Commerce.

U. S. Department of Commerce, Weather Bureau.

TABLE 28 *

CORN: PRODUCTION OF WORLD AND OF SELECTED COUNTRIES, 1900–1901 TO 1945–1947 †

Crop Year	Estimated World Production Excluding Russia	Estimated European Production Excluding Russia	Selected Countries: United States	Danube Basin Countries	Argentina	Brazil	Russia ‡	Italy	Union of South Africa
	million bushels	*million bushels*	*million bushels*	*million bushels*	*million bushels*	*million bushels*	*million bushels*	*million bushels*	*million bushels*
1900–01	3,750	445	2,662	269	99	...	34	88	2
1905–06	4,110	403	2,954	211	195	...	34	97	3
1910–11	4,118	564	2,853	375	28	...	102	104	31
1913–14	3,770	576	2,273	...	263	...	84	111	36
1914–15	4,041	558	2,524	...	325	...	90	105	40
1915–16	4,184	519	2,829	...	161	...	72	122	39
1916–17	3,635	389	2,425	...	59	204	62	82	43
1917–18	4,021	351	2,908	...	171	95	...	83	45
1918–19	3,517	299	2,441	...	224	87	...	77	41
1919–20	4,105	454	2,679	...	259	197	...	86	44
1920–21	4,551	519	3,071 §	354	230	186	46	89	48
1921–22	4,172	394	2,928	233	176	181	46	92	48
1922–23	4,044	424	2,707	275	176	202	118	77	71
1923–24	4,347	469	2,875	309	277	180	125	89	40
1924–25	3,886	589	2,298	404	186	162	92	106	87
1925–26	4,524	626	2,853	427	322	162	177	110	39
1926–27	4,360	653	2,575	468	321	164	136	118	65
1927–28	4,255	485	2,678	311	312	133	123	87	69
1928–29	4,247	384	2,715	250	252	194	130	65	67
1929–30	4,357	707	2,536	522	281	177	119	100	80
1930–31	3,959	612	2,065	400	420	187	105	118	57
1931–32	4,457	632	2,589	460	299	227	187	77	68
1932–33	4,826	765	2,907	555	268	238	135	119	30
1933–34	4,188	615	2,352	430	257	256	189	102	85
1934–35	3,432	729	1,377	507	451	228	151	126	63
1935–36	4,534	608	2,299	416	396	225	...	98	54
1936–37	3,912	787	1,506	561	340	227	...	120	101
1937–38	4,840	787	2,643	540	174	219	...	134	69
1938–39	4,768	745	2,549	511	191	212	...	116	104
1939–40	4,964	742	2,581	526	408	192	...	102	74
1940–41	4,933	758	2,457	529	403	214	...	135	87
1941–42	4,997	671	2,652	...	356	209	...	103	58
1942–43	5,165	675	3,069	...	76	203	...	96	79
1943–44	5,308	610	2,966	...	344	223	...	66	87
1944–45	5,165	578	3,088	...	117	200	...	86	66
1945–46	4,960	479	2,881	...	141	249	...	70	67
1946–47	4,625	680	2,447	134	...	...	125	92	...

* Bureau of Agricultural Economics, U. S. Department of Agriculture. Official sources and International Institute of Agriculture.

† Production figures refer to the year of harvest. Harvests of the northern hemisphere countries are combined with those of the southern hemisphere which immediately follow. Thus for 1934–1935 the crop harvested in the northern hemisphere countries in 1934 is combined with the southern hemisphere harvest which takes place early in 1935.

‡ Includes all Russian territory reporting for the years shown.

§ Production in present boundaries beginning this year, therefore not comparable with earlier years.

TABLE 29 *

CORN: DOMESTIC EXPORTS FROM THE UNITED STATES BY COUNTRIES, 1910–1947

Year Ended June 30	United Kingdom	Netherlands	Canada	Germany	Mexico	Cuba	Denmark	Belgium	France	Italy	Other Countries	Total
	thousand bushels	*thousand bushels*	*thousand bushels*	*thousand bushels*	*thousand bushels*	*thousand bushels*	*thousand bushels*	*thousand bushels*	*thousand bushels*	*thousand bushels*	*thousand bushels*	*thousand bushels*
1910	10,668	5,185	6,179	4,537	3,258	2,377	2,451	1,144	446	0	557	36,802
1915	2,850	15,876	8,283	16	1,587	2,267	11,170	104	3,773	70	2,790	48,786
1920	2,169	0	9,929	0	61	2,031	1	1	191	0	85	14,468
1921	11,423	10,144	20,298	10,844	5,635	2,121	4,401	955	165	27	898	66,911
1922	22,074	22,840	61,643	27,175	10,102	2,694	7,266	4,471	2,975	1,428	13,718	176,386
1923	21,271	13,962	32,154	11,807	288	2,778	3,320	1,931	3,174	861	2,418	94,064
1924	4,449	2,369	8,258	673	337	2,615	866	564	380	†	655	21,186
1925	141	77	4,239	26	1,366	2,267	0	0	5	†	339	8,460
1926	2,378	3,510	8,071	742	4,453	2,097	999	9	110	0	768	23,137
1927	1,268	560	10,536	2	2,124	2,016	553	69	12	24	399	17,563
1928	1,885	4,311	6,454	2,520	323	1,021	845	92	22	0	901	18,374
1929	8,237	6,262	11,082	4,241	572	765	896	688	982	2,587	4,432	40,744

1930	20	126	7,390	....	1,297	226	†	1	14	†	280	9,354
1931	13	50	1,226	69	756	47	1	2	16	†	179	2,359
1932	323	65	2,681	114	7	2	0	31	51	0	70	3,344
1933	1,001	759	5,183	156	9	47	197	519	153	†	169	8,193
1934	263	154	3,627	58	7	58	†	8	54	†	176	4,405
1935	12	2	1,791	†	1	†	†	§	11	0	39	1,856
1936 ‡	15	1	384	0	1	1	†	1	0	0	108	511
1937 ‡	17	1	63	0	26	†	†	0	13	0	16	136
1938 ‡	27,865	16,188	58,306	13,889	882	1	2,783	4,915	80	86	14,780	139,775
1939 ‡	11,287	5,906	11,845	180	1,444	1	125	303	382	†	2,407	33,880
1940 ‡	14,857	5,765	14,808	0	808	1	3,330	139	†	0	4,120	43,828
1941 ‡	7,415	0	6,731	0	1	2	0	0	0	0	406	14,555
1942 ‡	13,315	0	5,964	0	8	2	0	0	0	0	317	19,606
1943 ‡	1,119	0	3,186	0	465	1	0	0	0	0	34	4,805
1944 ‡	839	†	4,674	0	4,453	†	0	†	0	1	30	9,997
1945 ‡§	7,022	448	2,461	0	2,804	87	0	1,867	734	0	1,188	16,611
1946 ‡§	4	162	2,081	2,333	549	51	0	574	333	1,054	6,670	13,810
1947 ‡	6,900	5,300	6,400	10,700	29	46	....	3,900	13,600	17,500	22,200	134,000

* Bureau of Agricultural Economics, U. S. Department of Agriculture. Compiled from *Foreign Commerce and Navigation of the United States*, 1910–1918, monthly summary of foreign commerce of the United States, June issues, and official records of the Bureau of Foreign and Domestic Commerce, 1927–1935, inclusive.

† Less than 500 bushels.

‡ Year ending September 30, 1936–1946.

§ Excludes shipments during 1945–1946 of about 2,400,000 bushels to the military for civilian feeding in the occupied zones.

TABLE 30 *

CORN: ACREAGE IN THE CORN BELT STATES AND THE UNITED STATES, 1870–1947

Year	Ohio	Indiana	Illinois	Minnesota	Iowa	Missouri	South Dakota	Nebraska	Kansas	United States
	thousand acres	*thousand acres*	*thousand acres*	*thousand acres*	*thousand acres*	*thousand acres*	*thousand acres*	*thousand acres*	*thousand acres*	*thousand acres*
1870	2,600	2,325	6,350	190	2,550	2,550	.....	155	570	38,408
1875	3,250	3,175	8,150	350	4,600	4,760	.....	625	2,206	52,504
1880	3,150	3,425	8,840	495	6,950	5,650	.....	1,970	3,726	62,699
1881	3,050	3,450	9,100	560	6,530	5,650	.....	2,150	4,200	63,191
1882	3,100	3,350	8,800	750	6,740	5,760	179	2,460	4,662	66,157
1883	3,050	3,450	9,050	645	7,000	5,880	250	2,990	5,129	68,168
1884	3,075	3,525	8,640	660	7,360	6,000	446	3,500	4,960	68,834
1885	3,275	3,650	8,900	720	7,580	6,300	509	3,910	5,456	71,854
1886	3,175	3,650	8,900	750	7,960	6,480	636	4,380	6,301	73,911
1887	3,200	3,700	8,140	820	8,120	6,400	611	4,740	5,666	73,296
1888	3,450	3,850	8,630	870	8,440	6,540	630	5,120	7,566	77,474
1889	3,350	3,775	8,900	925	8,610	6,800	786	5,480	7,319	77,656
1890	3,300	3,875	9,300	965	8,790	6,860	850	5,525	3,807	74,785
1891	3,350	3,975	9,700	935	9,040	6,800	980	6,150	5,386	78,855
1892	3,300	3,725	8,720	905	7,860	6,250	835	5,975	5,791	76,914
1893	3,450	3,900	9,150	1,035	8,180	6,500	910	6,400	6,391	79,832
1894	3,600	4,100	9,520	1,100	8,750	7,010	375	6,825	3,576	80,069
1895	3,775	4,300	10,000	1,360	9,070	7,200	1,180	7,300	8,400	90,479
1896	4,000	4,500	9,925	1,405	9,160	7,125	1,260	7,425	8,008	89,074
1897	3,800	4,400	10,500	1,320	9,020	7,500	1,070	7,500	8,408	89,965
1898	3,900	4,375	9,760	1,410	8,660	7,250	1,080	7,000	7,315	87,784
1899	3,860	4,568	10,060	1,442	8,840	7,480	1,225	7,380	8,266	94,591

1900	4,000	5,025	10,460	1,480	9,100	7,700	1,280	7,350	7,472	94,852
1901	3,875	5,050	10,700	1,610	9,460	7,550	1,450	7,175	6,836	94,422
1902	4,000	5,225	10,850	1,800	9,560	7,550	1,660	7,350	7,140	97,177
1903	3,900	5,150	10,550	1,790	8,410	7,050	1,700	7,075	6,707	93,555
1904	3,975	5,450	10,500	1,950	9,550	6,650	1,750	7,275	6,707	95,228
1905	3,750	5,000	10,500	1,940	9,600	7,080	1,830	7,200	7,042	95,746
1906	3,900	5,075	10,500	1,990	9,650	6,980	1,875	7,075	6,819	95,624
1907	3,800	4,950	10,400	1,950	9,700	7,080	1,850	7,075	7,087	96,094
1908	3,750	4,875	9,800	2,100	9,350	6,500	1,940	7,150	7,386	95,285
1909	4,030	5,095	10,173	2,067	9,041	7,220	2,068	7,327	8,109	100,200
1910	3,925	4,950	10,150	2,190	9,530	7,500	2,150	7,425	8,950	102,267
1911	3,900	4,950	9,800	2,430	9,850	7,400	2,350	7,350	8,157	101,393
1912	3,950	5,050	10,000	3,610	9,920	7,610	2,650	7,500	7,575	101,451
1913	3,850	5,100	9,850	2,720	9,720	7,480	2,825	7,650	7,320	100,206
1914	3,725	5,150	9,650	3,025	9,850	7,370	3,150	7,350	5,850	97,796
1915	3,800	5,250	9,500	3,090	9,900	7,220	3,250	7,350	5,550	100,623
1916	3,900	5,330	9,550	2,860	9,800	7,400	3,000	7,600	6,950	100,561
1917	4,200	5,875	10,100	3,230	10,500	8,020	3,350	8,350	9,156	110,893
1918	3,875	5,350	9,650	3,010	9,800	7,300	3,240	7,000	6,130	102,195
1919	4,047	5,172	8,650	3,258	9,959	6,272	3,408	7,080	4,370	98,145
1920	3,925	5,320	9,169	3,747	10,300	6,646	3,875	7,660	5,331	101,359
1921	3,730	5,040	8,912	3,859	10,250	6,095	3,992	7,520	4,638	103,155
1922	3,581	4,960	8,377	4,052	10,364	6,250	4,071	7,440	5,195	100,345
1923	3,653	5,295	8,628	4,376	10,776	6,562	4,493	8,500	5,713	101,123
1924	3,432	4,688	8,946	4,595	10,912	6,300	4,814	8,718	6,056	100,420
1925	3,707	4,922	9,393	4,273	11,234	6,741	4,765	9,300	6,722	101,331
1926	3,596	4,824	9,205	4,529	11,195	6,471	4,755	9,290	5,781	99,452
1927	3,344	4,293	8,469	4,302	10,980	5,796	4,955	9,160	6,241	98,357
1928	3,612	4,636	9,231	4,216	11,300	6,260	4,850	9,250	6,988	100,336
1929	3,473	4,253	8,575	4,359	11,048	5,566	5,095	9,516	6,643	97,806

TABLE 30 * (*Continued*)

CORN: ACREAGE IN THE CORN BELT STATES AND THE UNITED STATES, 1870–1947

Year	Ohio	Indiana	Illinois	Minnesota	Iowa	Missouri	South Dakota	Nebraska	Kansas	United States
	thousand acres	*thousand acres*	*thousand acres*	*thousand acres*	*thousand acres*	*thousand acres*	*thousand acres*	*thousand acres*	*thousand acres*	*thousand acres*
1930	3,438	4,466	9,004	4,533	11,335	6,345	5,146	9,564	6,776	100,083
1931	3,576	4,734	9,544	4,896	11,732	6,472	4,837	10,042	6,573	105,948
1932	3,433	4,639	9,353	4,945	11,849	6,472	5,030	10,644	7,362	108,668
1933	3,364	4,314	8,324	4,846	11,375	6,019	3,873	10,431	6,994	103,260
1934	2,927	3,883	7,159	4,507	8,986	4,815	2,827	6,676	3,777	87,795
1935	3,649	4,270	8,195	4,473	9,826	3,940	3,707	8,078	4,380	95,974
1936	3,685	4,569	9,178	4,585	10,759	5,004	2,484	7,674	2,759	93,154
1937	3,796	4,752	9,270	4,791	11,082	4,360	3,130	7,904	2,456	93,930
1938	3,568	4,182	8,436	4,480	10,417	4,360	2,974	7,430	2,260	92,160
1939	3,425	4,098	7,869	4,480	9,400	4,281	2,706	6,538	2,757	88,279
1940	3,185	3,934	7,645	4,366	9,024	4,067	2,787	6,211	2,647	86,429
1941	3,217	3,934	7,721	4,410	9,069	3,904	2,703	6,708	2,488	85,357
1942	3,249	4,013	7,721	4,763	9,568	4,138	3,081	7,245	3,110	87,367
1943	3,444	4,254	8,384	5,192	10,716	4,510	3,543	8,332	3,514	92,060
1944	3,651	4,594	9,140	5,867	11,037	4,781	3,897	8,749	3,549	94,014
1945	3,468	4,364	8,130	5,926	10,706	3,873	4,092	8,487	2,981	88,079
1946	3,641	4,539	9,024	5,452	11,027	4,648	4,010	7,978	3,011	88,718
1947	3,386	4,445	8,696	5,324	10,355	4,018	3,970	7,340	2,379	83,981

* Bureau of Agricultural Economics, U. S. Department of Agriculture. Compiled from records of the Division of Crop and Livestock Estimates

TABLE 31 *

Corn: Yield per Acre in the Corn Belt States and the United States

Year	Ohio	Indiana	Illinois	Minnesota	Iowa	Missouri	South Dakota	Nebraska	Kansas	United States
	bushels	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*
1877	32.5	35.0	27.0	26.5	33.5	29.0	....	34.0	34.0	25.7
1878	36.0	32.0	29.0	36.5	40.5	26.0	....	41.0	28.5	26.2
1879	34.1	31.4	36.1	33.8	41.6	36.2	....	40.1	30.9	28.1
1880	39.0	25.5	31.0	31.0	39.5	28.5	....	31.0	29.5	27.2
1881	31.0	22.0	21.0	31.0	30.0	16.5	....	29.5	18.0	19.7
1882	34.0	34.0	25.0	27.0	30.5	33.5	25.0	38.0	33.5	26.5
1883	26.0	29.0	27.5	21.0	29.0	28.0	20.0	37.5	36.5	24.2
1884	33.0	31.0	33.0	32.0	39.5	34.0	30.0	41.0	37.0	28.3
1885	39.0	36.0	34.5	28.0	36.5	31.5	29.0	40.0	32.5	28.6
1886	34.0	34.0	28.0	31.0	29.0	24.0	21.5	31.0	22.0	24.1
1887	31.0	22.0	21.0	27.0	30.0	23.0	27.0	27.5	14.5	21.9
1888	38.5	37.0	40.0	28.0	39.5	31.0	25.5	38.0	26.5	29.1
1889	35.7	30.4	36.8	27.4	41.3	32.4	17.5	39.4	35.5	29.5
1890	25.0	25.0	28.0	27.0	28.0	28.0	13.5	20.0	10.5	22.1
1891	37.5	36.0	38.0	26.5	40.5	30.0	27.0	37.5	26.5	29.6
1892	31.0	31.0	27.0	27.0	30.5	28.0	27.0	32.0	24.5	24.7
1893	29.0	24.0	26.0	28.0	37.5	30.5	30.0	26.5	21.5	23.8
1894	30.5	30.0	31.0	18.5	15.0	24.0	4.0	7.0	11.0	20.2
1895	33.5	36.0	41.0	30.5	39.0	37.0	11.0	16.5	24.5	28.0
1896	42.0	39.5	42.0	30.5	43.0	29.5	30.0	37.5	28.0	30.0
1897	35.0	30.5	34.0	28.0	33.5	26.0	27.0	30.0	19.0	25.4
1898	40.0	38.5	31.0	30.5	36.0	30.0	28.0	21.0	19.0	26.8
1899	39.7	39.8	38.8	32.8	39.1	28.1	27.1	28.8	27.8	28.0
1900	42.5	41.5	40.0	33.0	45.0	29.5	27.0	26.0	19.0	28.1
1901	30.0	22.0	24.0	27.0	28.5	10.0	21.0	14.0	8.0	18.2
1902	40.0	39.0	41.0	23.0	38.0	39.0	19.0	32.5	30.0	28.5
1903	32.5	35.0	35.5	27.5	32.5	29.5	25.0	27.5	26.0	26.9
1904	35.5	33.0	39.0	25.5	39.0	26.0	23.0	33.0	21.0	28.2
1905	39.5	42.0	42.0	34.0	41.5	34.0	30.5	34.0	28.0	30.9
1906	43.0	41.0	39.0	34.0	45.5	32.5	30.5	34.0	29.0	31.7
1907	36.0	36.5	39.0	27.0	35.0	31.0	21.5	24.0	22.0	27.2
1908	38.5	30.5	35.0	29.0	38.0	27.0	26.0	27.0	22.0	26.9
1909	40.2	39.9	38.8	33.9	37.1	26.9	27.3	24.8	19.1	26.1
1910	36.5	39.0	41.0	32.0	41.5	33.0	21.0	26.0	19.0	27.9
1911	39.5	34.5	36.0	33.0	35.5	26.0	19.5	21.5	14.5	24.4
1912	41.5	39.5	40.0	34.0	46.0	32.0	26.5	27.0	23.0	29.1
1913	37.5	35.5	28.0	38.0	37.5	17.5	22.5	15.0	3.0	22.7
1914	39.0	33.0	31.0	35.0	40.5	22.0	22.0	24.5	18.5	25.8
1915	40.5	38.5	38.0	23.0	32.5	29.5	26.0	31.0	31.0	28.1
1916	31.5	32.5	31.0	33.0	38.0	19.5	24.5	27.0	10.0	24.1
1917	37.0	35.5	40.0	27.0	38.5	33.5	24.0	27.0	13.0	26.2
1918	36.0	35.0	36.5	37.0	37.0	20.0	30.0	18.0	7.0	23.9
1919	41.5	35.6	36.0	35.5	41.6	26.5	25.5	24.0	15.5	27.3

TABLE 31 * (*Continued*)

Corn: Yield per Acre in the Corn Belt States and the United States

Year	Ohio	Indiana	Illinois	Minnesota	Iowa	Missouri	South Dakota	Nebraska	Kansas	United States
	bushels	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*
1920	40.0	39.5	35.0	33.5	46.0	31.5	30.0	33.2	26.2	30.3
1921	39.5	36.0	35.0	38.5	43.0	30.5	32.0	27.0	22.8	28.4
1922	37.0	36.0	35.5	29.5	45.0	28.5	28.5	24.0	19.0	27.0
1923	40.0	38.0	37.5	35.0	40.5	30.0	32.0	32.0	23.0	28.4
1924	27.0	26.5	33.0	26.5	28.0	26.5	21.3	22.5	23.5	22.9
1925	46.0	43.5	42.0	34.5	43.9	30.0	17.5	25.0	17.6	28.2
1926	38.5	38.0	36.0	32.0	39.0	27.5	18.0	15.5	11.0	25.9
1927	33.0	31.5	31.5	28.5	35.0	29.0	30.0	32.1	30.0	27.2
1928	35.5	35.2	38.4	33.0	41.5	30.0	21.0	22.0	27.0	27.1
1929	34.5	31.0	35.5	36.0	40.2	23.5	23.7	25.5	17.5	25.9
1930	25.5	26.2	26.0	31.0	34.0	14.0	16.0	25.0	12.0	20.4
1931	45.0	39.0	37.0	23.5	32.9	27.5	5.2	17.0	17.5	24.4
1932	35.5	37.5	43.0	36.5	43.0	30.5	14.7	25.3	18.5	26.8
1933	33.5	29.5	27.0	29.5	40.0	23.5	10.6	22.5	11.5	22.8
1934	31.5	24.8	20.5	17.0	21.8	5.5	4.5	3.2	2.8	15.7
1935	44.0	38.0	38.5	33.0	38.0	18.5	13.5	13.2	9.0	24.0
1936	33.0	25.5	23.5	18.0	17.7	8.0	3.4	3.5	4.0	16.2
1937	43.0	45.0	48.0	36.0	45.0	27.0	13.5	10.5	12.0	28.1
1938	44.0	41.0	44.0	35.5	46.0	25.5	12.0	15.0	20.0	27.7
1939	49.5	50.0	51.0	45.0	52.2	29.5	17.5	12.0	14.0	29.2
1940	38.0	37.0	43.0	39.5	52.5	30.5	17.5	17.0	16.0	28.4
1941	49.5	45.0	53.0	43.0	51.0	29.0	18.0	23.5	22.5	31.1
1942	56.0	54.0	54.0	43.5	60.0	35.5	31.5	31.5	26.5	35.1
1943	51.0	49.0	50.0	40.5	55.0	31.0	22.0	26.0	22.0	32.2
1944	40.3	40.1	45.4	41.5	52.5	33.0	33.0	33.0	27.5	32.8
1945	50.5	53.0	46.5	36.5	44.5	27.0	27.0	28.5	23.0	32.7
1946	49.0	51.0	57.0	44.0	60.0	37.0	30.0	29.0	21.0	37.1
1947	41.0	43.0	39.5	36.5	32.0	24.5	19.0	19.5	17.0	28.6
1948	58.5	60.0	61.0	52.5	61.0	45.5	36.0	36.0	33.5	42.7

* Bureau of Agricultural Economics, U. S. Department of Agriculture. Compiled from records of the Division of Crop and Livestock Estimates.

TABLE 32 *

CORN: PRODUCTION IN THE CORN BELT STATES AND THE UNITED STATES

Year	Ohio	Indiana	Illinois	Minnesota	Iowa	Missouri	South Dakota	Nebraska	Kansas	United States
	million bushels	*million bushels*	*million bushels*	*million bushels*	*million bushels*	*million bushels*	*million bushels*	*million bushels*	*million bushels*	*million bushels*
1877	111	129	242	11	194	146	...	38	99	1,516
1878	124	118	244	15	247	132	...	55	78	1,565
1879	112	115	326	15	275	202	...	65	106	1,752
1880	123	87	274	15	275	161	...	61	110	1,707
1881	95	76	191	17	196	93	...	63	76	1,245
1882	105	114	220	20	206	193	4	93	156	1,755
1883	79	100	247	14	203	165	5	112	187	1,651
1884	101	109	285	21	291	204	13	144	184	1,948
1885	128	131	307	20	277	198	15	156	177	2,058
1886	108	124	247	23	231	156	14	136	139	1,783
1887	99	81	171	22	244	147	16	130	82	1,605
1888	133	142	345	24	333	203	16	195	200	2,251
1889	120	115	328	25	356	220	14	216	260	2,294
1890	82	97	260	26	246	192	11	110	40	1,650
1891	126	143	369	25	366	204	26	231	143	2,336
1892	102	115	235	24	240	175	23	191	142	1,897
1893	100	94	238	29	307	198	27	170	137	1,900
1894	110	123	295	20	131	168	2	48	39	1,615
1895	126	155	410	41	354	266	13	120	206	2,535
1896	168	178	417	43	394	210	38	278	224	2,671
1897	133	134	357	37	302	195	29	225	160	2,287
1898	156	168	303	43	312	218	30	147	139	2,351
1899	153	182	390	47	346	210	33	213	230	2,646
1900	170	209	418	49	410	227	35	191	142	2,662
1901	116	111	257	43	270	76	30	100	55	1,716
1902	160	204	445	41	363	294	32	239	214	2,774
1903	127	180	375	49	273	208	42	195	174	2,515
1904	141	180	410	50	372	173	40	240	141	2,687
1905	148	210	441	66	398	241	56	245	197	2,954
1906	168	208	410	68	439	227	57	241	198	3,033
1907	137	181	406	53	340	219	40	170	156	2,614
1908	144	149	343	58	355	176	50	193	162	2,567
1909	162	203	395	70	349	194	56	182	155	2,611
1910	143	193	416	70	395	248	45	193	170	2,853
1911	154	171	353	80	350	192	46	158	118	2,475
1912	164	199	400	89	456	244	70	202	174	2,948
1913	144	181	276	103	364	131	64	115	22	2,273
1914	145	170	299	106	399	162	69	180	108	2,524
1915	154	202	361	71	322	213	84	228	172	2,829
1916	123	174	296	94	372	144	74	205	70	2,425
1917	155	209	404	87	404	269	80	225	119	2,908
1918	140	187	352	111	363	146	97	126	43	2,441
1919	168	184	311	116	414	166	87	170	68	2,679

TABLE 32 * (*Continued*)

Corn: Production in the Corn Belt States and the United States

Year	Ohio	Indiana	Illinois	Minnesota	Iowa	Missouri	South Dakota	Nebraska	Kansas	United States
	million bushels	*million bushels*	*million bushels*	*million bushels*	*million bushels*	*million bushels*	*million bushels*	*million bushels*	*million bushels*	*million bushels*
1920	157	210	321	126	474	209	116	254	140	3,071
1921	147	181	312	149	441	186	128	203	106	2,928
1922	132	179	297	120	466	178	116	179	99	2,707
1923	146	201	324	153	436	197	144	272	131	2,875
1924	93	124	295	122	306	167	103	196	142	2,298
1925	171	214	395	147	493	202	83	230	118	2,853
1926	138	183	331	145	437	178	86	144	64	2,575
1927	110	135	267	123	384	168	149	294	187	2,678
1928	128	163	354	139	469	188	102	204	189	2,715
1929	120	132	304	157	444	131	121	243	116	2,536
1930	88	117	234	141	385	89	82	239	81	2,065
1931	161	185	353	115	386	178	25	171	115	2,589
1932	122	174	402	180	510	197	74	269	136	2,907
1933	113	127	225	143	455	141	41	235	80	2,352
1934	92	96	147	77	196	26	13	21	11	1,377
1935	161	162	316	148	373	73	50	107	39	2,299
1936	122	117	216	83	190	40	8	27	11	1,506
1937	163	214	445	172	499	118	42	83	29	2,643
1938	157	171	371	159	479	111	36	111	45	2,549
1939	170	205	401	202	491	126	47	78	39	2,581
1940	121	146	329	172	474	124	49	106	42	2,457
1941	159	177	409	190	463	113	49	158	56	2,652
1942	182	217	417	207	574	147	97	228	82	3,069
1943	176	208	419	210	589	140	78	217	77	2,966
1944	147	184	415	243	579	158	129	289	98	3,088
1945	175	231	378	216	476	105	110	242	69	2,881
1946	178	231	514	240	662	172	120	231	63	3,288
1947	139	191	343	191	331	98	75	143	40	2,401
1948	216	280	550	272	667	201	131	252	81	3,651

* Bureau of Agricultural Economics, U. S. Department of Agriculture. Compiled from records of the Division of Crop and Livestock Estimates.

TABLE 33 *

PERCENTAGE OF TOTAL CORN ACREAGE PLANTED WITH HYBRID SEED, 1933–1941

State	1933	1934	1935	1936	1937	1938	1939	1940	1941
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Me.	....	....	....	....	....	....	....	....	1.0
N. H.	....	....	....	....	....	....	1.0	3.0	10.0
Vt.	....	....	....	....	....	1.0	2.0	6.0	18.0
Mass.	....	....	....	....	....	1.0	4.0	12.0	20.0
R. I.	....	....	....	....	....	1.0	3.0	7.0	20.0
Conn.	....	....	....	1.0	2.0	4.0	12.0	20.0	32.0
N. Y.	....	....	....	0.3	1.1	3.3	7.9	12.1	17.8
N. J.	....	....	....	0.4	1.0	2.4	5.4	20.1	35.0
Pa.	....	....	....	0.1	0.9	3.4	8.3	14.7	25.1
Ohio	....	....	0.4	2.0	6.7	25.0	42.1	56.0	74.7
Ind.	....	0.3	1.0	3.5	11.1	28.5	50.8	63.1	83.1
Ill.	0.6	1.5	4.1	9.9	25.2	47.5	65.5	76.4	86.9
Mich.	....	....	0.1	0.5	1.1	3.2	8.1	20.9	41.6
Wis.	0.1	0.6	1.8	5.0	11.1	24.0	39.7	56.6	70.1
Minn.	0.1	0.4	1.4	3.7	9.1	20.4	37.0	57.6	72.4
Iowa	0.7	2.1	6.0	14.4	30.7	51.9	73.4	90.3	96.9
Mo.	....	....	....	0.3	0.6	1.8	12.1	26.9	46.7
N. Dak.	....	....	....	....	....	0.4	1.6	3.8	7.6
S. Dak.	....	....	0.1	0.4	1.2	3.1	7.0	12.6	24.7
Neb.	†	0.1	0.3	1.0	2.5	6.8	12.7	24.9	36.5
Kans.	....	....	....	....	0.2	1.6	5.3	11.1	18.1
Del.	....	....	....	....	0.2	1.2	2.9	6.2	17.6
Md.	....	....	....	†	0.5	2.0	6.0	14.5	27.9
Va.	....	....	....	†	0.2	0.4	0.9	2.3	4.4
W. Va.	....	....	....	0.1	0.6	1.9	4.0	8.0	12.3
N. C.	....	....	....	....	....	0.1	0.2	0.5	0.9
S. C.	....	....	....	....	....	....	....	....	1.0
Ga.	....	....	....	....	....	....	....	....	1.0
Fla.	....	....	....	....	....	....	....	....	0.7
Ky.	....	....	....	0.2	0.8	1.8	4.1	8.2	13.5
Tenn.	....	....	....	†	†	0.3	0.9	2.1	4.6
Ala.	....	....	....	....	....	†	0.1	0.3	0.8
Miss.	....	....	....	....	....	0.2	1.0	2.2	2.8
Ark.	....	....	....	....	....	0.3	1.4	3.4	6.5
La.	....	....	....	....	....	0.1	0.4	1.0	2.1
Okla.	....	....	....	....	....	0.3	1.5	2.4	4.9
Tex.	....	....	....	....	....	....	....	....	0.7
Mont.	....	....	....	....	....	....	....	0.9	2.2
Idaho	....	....	....	....	....	3.7	9.4	21.2	34.5
Wyo.	....	....	....	....	....	....	0.1	0.6	2.1
Colo.	....	....	....	....	†	0.4	0.9	1.9	5.1
N. Mex.	....	....	....	....	....	....	0.1	1.2	3.1
Ariz.	....	....	....	....	....	....	....	....	....
Utah	....	....	....	....	....	0.1	0.8	2.8	8.2
Nev.	....	....	....	....	....	....	....	0.7	1.4
Wash.	....	....	....	....	....	2.0	7.0	16.3	24.2
Ore.	....	....	....	....	....	1.4	5.1	12.9	25.1
Calif.	....	....	....	....	....	....	....	....	....
U. S. total	0.1	0.4	1.1	3.1	7.9	14.9	22.5	30.4	39.1

* Bureau of Agricultural Economics, U. S. Department of Agriculture.
† Less than one-tenth of 1 per cent.

TABLE 34 *

State	All Corn Acreage	Percentage Planted with Hybrid Seed	Indicated Hybrid Corn Acreage
	thousand acres	*per cent*	*thousand acres*
	CORN ACREAGE PLANTED WITH HYBRID SEED, 1942 §		
Me.	16	9.0	1
N. H.	15	15.0	2
Vt.	70	23.0	16
Mass.	41	30.0	12
R. I.	8	30.0	2
Conn.	49	45.0	22
N. Y.	696	22.0	153
N. J.	187	46.6	87
Pa.	1308	36.1	472
Ohio	3,327	86.7	2,885
Ind.	4,017	92.8	3,727
Ill.	8,050	93.3	7,514
Mich.	1,645	55.2	908
Wis.	2,430	76.5	1,859
Minn.	4,825	83.0	4,005
Iowa	9,763	98.9	9,652
Mo.	4,403	60.1	2,647
N. Dak.	1,235	12.3	152
S. Dak.	3,169	33.9	1,074
Neb.	7,318	51.4	3,764
Kans.	3,254	24.4	794
Del.	133	21.8	29
Md.	457	39.0	178
Va.	1,332	7.6	101
W. Va.	417	21.9	91
N. C.	2,309	1.3	30
S. C.	1,478	0.3	4
Ga.	3,589	0.9	32
Fla.	711	0.8	6

TABLE 34 * (*Continued*)

State	All Corn Acreage	Percentage Planted with Hybrid Seed	Indicated Hybrid Corn Acreage
	thousand acres	*per cent*	*thousand acres*
CORN ACREAGE PLANTED WITH HYBRID SEED, 1942 (*Continued*)			
Ky.	2,767	22.7	628
Tenn.	2,826	5.8	164
Ala.	3,172	1.1	35
Miss.	2,909	3.3	96
Ark.	2,108	6.9	145
La.	1,424	2.2	31
Okla.	2,016	4.3	87
Tex.	5,638	1.2	68
Mont.	198	2.5	5
Idaho	53	51.2	27
Wyo.	130	2.7	4
Colo.	1,068	7.8	83
N. Mex.	219	4.4	10
Ariz.	38	†	..
Utah	25	10.8	3
Nev.	4	6.1	..
Wash.	33	36.0	12
Ore.	53	36.5	19
Calif.	78	†	..
U. S. total	91,011	45.7	41,636
CORN ACREAGE PLANTED WITH HYBRID SEED, 1943 §			
Me.	16	17.0	3
N. H.	15	20.0	3
Vt.	64	30.0	19
Mass.	41	35.0	14
R. I.	8	45.0	4
Conn.	48	55.0	26
N. Y.	654	29.8	195
N. J.	181	72.3	131
Pa.	1,298	44.7	580

TABLE 34 * (*Continued*)

State	All Corn Acreage	Percentage Planted with Hybrid Seed	Indicated Hybrid Corn Acreage
	thousand acres	*per cent*	*thousand acres*
CORN ACREAGE PLANTED WITH HYBRID SEED, 1943 (*Continued*)			
Ohio	3,544	91.5	3,243
Ind.	4,338	95.9	4,160
Ill.	8,621	96.1	8,285
Mich.	1,562	62.9	982
Wis.	2,529	81.2	2,054
Minn.	5,356	87.5	4,686
Iowa	10,937	99.3	10,860
Mo.	4,931	70.7	3,486
N. Dak.	1,188	16.3	194
S. Dak.	3,834	43.8	1,679
Neb.	8,502	63.5	5,399
Kans.	3,872	30.1	1,165
Del.	130	26.2	34
Md.	457	46.8	214
Va.	1,345	12.7	171
W. Va.	417	29.5	123
N. C.	2,335	1.7	40
S. C.	1,561	0.7	11
Ga.	3,804	0.6	23
Fla.	747	4.8	36
Ky.	2,753	35.8	986
Tenn.	2,883	7.8	225
Ala.	3,257	1.5	49
Miss.	2,880	3.6	104
Ark.	2,108	8.0	169
La.	1,431	1.9	27
Okla.	2,097	4.9	103
Tex.	5,610	1.5	84

TABLE 34 * (*Continued*)

State	All Corn Acreage	Percentage Planted with Hybrid Seed	Indicated Hybrid Corn Acreage
	thousand acres	*per cent*	*thousand acres*
CORN ACREAGE PLANTED WITH HYBRID SEED, 1943 (*Continued*)			
Mont.	198	2.8	6
Idaho	36	54.3	20
Wyo.	124	3.2	4
Colo.	987	14.6	144
N. Mex.	210	5.5	12
Ariz.	37	..	..
Utah	29	21.7	6
Nev.	4	9.8	..
Wash.	31	41.9	13
Ore.	52	43.0	22
Calif.	74	23.0	17
U. S. total	97,136	51.3	49,811
CORN ACREAGE PLANTED WITH HYBRID SEED, 1944 §			
Me.	17	30.0	5
N. H.	16	35.0	6
Vt.	65	36.0	23
Mass.	46	50.0	23
R. I.	8	55.0	4
Conn.	52	55.0	29
N. Y.	732	31.0	227
N. J.	194	69.0	134
Pa.	1,402	54.0	757
Ohio	3,828	94.0	3,598
Ind.	4,685	97.0	4,544
Ill.	9,224	96.0	8,855
Mich.	1,812	71.0	1,287
Wis.	2,706	85.0	2,300
Minn.	5,999	89.0	5,339
Iowa	11,484	99.0	11,369

TABLE 34 * (*Continued*)

State	All Corn Acreage	Percentage Planted with Hybrid Seed	Indicated Hybrid Corn Acreage
	thousand acres	*per cent*	*thousand acres*
CORN ACREAGE PLANTED WITH HYBRID SEED, 1944 (*Continued*)			
Mo.	5,030	79.0	3,974
N. Dak.	1,283	22.0	282
S. Dak.	3,987	54.0	2,153
Neb.	9,012	72.0	6,489
Kans.	3,756	44.0	1,653
Del..	139	32.0	44
Md.	503	57.0	287
Va.	1,399	23.0	322
W. Va.	425	31.0	132
N. C.	2,358	2.0	47
S. C.	1,467	1.0	15
Ga.	3,652	1.0	37
Fla.	732	11.0	81
Ky.	2,891	49.0	1,417
Tenn.	2,710	10.0	271
Ala.	3,192	2.0	64
Miss.	2,707	4.0	108
Ark.	2,045	14.0	286
La.	1,317	4.0	53
Okla.	1,971	7.0	138
Tex.	5,049	3.0	151
Mont.	208	4.0	8
Idaho	32	61.0	20
Wyo.	103	5.0	5
Colo.	957	21.0	201
N. Mex	200	10.0	20
Ariz.	40	..	..
Utah	26	34.0	9
Nev.	4	14.0	1

TABLE 34 * (*Continued*)

State	All Corn Acreage	Percentage Planted with Hybrid Seed	Indicated Hybrid Corn Acreage
	thousand acres	*per cent*	*thousand acres*
CORN ACREAGE PLANTED WITH HYBRID SEED, 1944 (*Continued*)			
Wash.	31	48.0	15
Ore.	43	52.0	22
Calif.	67	20.0	13
U. S. total	99,606	57.0	56,818
CORN ACREAGE PLANTED WITH HYBRID SEED, 1945			
Me.	15	32.0	5
N. H.	14	45.0	6
Vt.	66	46.0	30
Mass.	38	52.0	20
R. I.	8	60.0	5
Conn.	50	60.0	30
N. Y.	717	40.6	291
N. J.	179	74.6	134
Pa.	1,364	67.2	917
Ohio	3,592	95.9	3,445
Ind.	4,503	98.1	4,417
Ill.	8,537	98.1	8,375
Mich.	1,794	79.6	1,428
Wis.	2,706	88.8	2,403
Minn.	6,059	91.2	5,526
Iowa	11,071	99.9	11,060
Mo.	4,107	87.7	3,602
N. Dak.	1,283	31.9	409
S. Dak.	4,268	62.8	2,680
Neb.	8,561	85.1	7,285
Kans.	3,117	62.0	1,933
North-central states total ‡	59,598	88.2	52.563

TABLE 34 * (*Continued*)

State	All Corn Acreage	Percentage Planted with Hybrid Seed	Indicated Hybrid Corn Acreage
	thousand acres	*per cent*	*thousand acres*
CORN ACREAGE PLANTED WITH HYBRID SEED, 1945 (*Continued*)			
Del.	133	46.1	61
Md.	461	64.9	299
Va.	1,235	40.3	498
W. Va.	364	40.4	147
N. C.	2,250	3.2	72
S. C.	1,426	1.3	19
Ga.	3,512	1.7	60
Fla.	695	10.6	74
Ky.	2,443	64.8	1,583
Tenn.	2,465	14.9	367
Ala.	2,996	2.4	72
Miss.	2,572	4.8	123
Ark.	1,764	28.3	499
La.	1,187	4.8	57
Okla.	1,596	15.0	239
Tex.	4,262	11.8	503
Mont.	149	5.0	7
Idaho	30	55.6	17
Wyo.	110	5.2	6
Colo.	790	25.6	202
N. Mex.	178	8.0	14
Ariz.	40	3.3	1
Utah	25	51.3	13
Nev.	2	37.8	1
Wash.	29	54.0	16
Ore.	40	55.0	22
Calif.	64	21.8	14
U. S. total	92,867	63.5	58,987

TABLE 34 * (*Continued*)

State	All Corn Acreage	Percentage Planted with Hybrid Seed	Indicated Hybrid Corn Acreage
	thousand acres	*per cent*	*thousand acres*
Corn Acreage Planted with Hybrid Seed, 1946 §			
Me.	11	45.0	5
N. H.	13	52.0	7
Vt.	58	53.0	31
Mass.	48	62.0	24
R. I.	8	65.0	5
Conn.	50	65.0	32
N. Y.	689	58.0	400
N. J.	190	81.0	154
Pa.	1,397	74.0	1,034
Ohio	3,671	97.0	3,561
Ind.	4,557	98.5	4,489
Ill.	9,097	99.0	9,006
Mich.	1,830	85.0	1,556
Wis.	2,571	92.0	2,365
Minn.	5,514	94.0	5,183
Iowa	11,064	100.0	11,064
Mo.	4,710	90.5	4,263
N. Dak.	1,219	47.0	573
S. Dak.	4,097	62.0	2,540
Neb.	8,062	89.0	7,175
Kans.	3,154	73.0	2,302
Del.	145	67.0	97
Md.	458	75.0	344
Va.	1,125	55.0	619
W. Va.	303	53.0	161
N. C.	2,215	5.5	122
S. C.	1,452	2.5	36
Ga.	3,313	2.5	83
Fla.	703	7.5	53

TABLE 34 * (*Continued*)

State	All Corn Acreage	Percentage Planted with Hybrid Seed	Indicated Hybrid Corn Acreage
	thousand acres	*per cent*	*thousand acres*
CORN ACREAGE PLANTED WITH HYBRID SEED, 1946 (*Continued*)			
Ky.	2,253	73.0	1,645
Tenn.	2,207	23.0	508
Ala.	2,743	3.0	82
Miss.	2,417	5.5	133
Ark.	1,509	39.0	589
La.	1,040	8.0	83
Okla.	1,534	27.0	414
Tex.	3,267	23.0	751
Mont.	190	12.0	23
Idaho	27	48.0	13
Wyo.	73	7.0	5
Colo.	717	30.0	215
N. Mex.	160	9.0	14
Ariz.	34	3.0	1
Utah	22	54.0	12
Nev.	2	41.0	1
Wash.	17	51.0	9
Ore.	34	64.0	22
Calif.	67	30.0	20
U. S. total	90,027	68.7	61,824
CORN ACREAGE PLANTED WITH HYBRID SEED, 1947 §			
Me.	10	57.0	6
N. H.	13	62.0	8
Vt.	57	58.0	33
Mass.	36	68.0	24
R. I.	8	68.0	5
Conn.	47	68.0	32
N. Y.	634	69.0	437
N. J.	175	86.0	150
Pa.	1,369	80.0	1,095

TABLE 34 * (*Continued*)

State	All Corn Acreage	Percentage Planted with Hybrid Seed	Indicated Hybrid Corn Acreage
	thousand acres	*per cent*	*thousand acres*
CORN ACREAGE PLANTED WITH HYBRID SEED, 1947 (*Continued*)			
Ohio	3,451	97.5	3,365
Ind.	4,375	99.0	4,331
Ill.	9,097	99.0	9,006
Mich.	1,610	88.0	1,417
Wis.	2,571	92.5	2,378
Minn.	5,404	94.0	5,080
Iowa	10,400	100.0	10,400
Mo.	4,522	92.5	4,183
N. Dak.	1,109	48.0	532
S. Dak.	4,097	70.0	2,868
Neb.	7,578	92.0	6,972
Kans.	2,523	79.0	1,993
Del.	142	75.0	106
Md.	449	90.0	404
Va.	1,136	67.0	761
W. Va.	303	57.0	173
N. C.	2,215	8.0	177
S. C.	1,437	5.0	72
Ga.	3,346	2.5	84
Fla.	703	9.0	63
Ky.	2,185	78.0	1,704
Tenn.	2,207	30.0	662
Ala.	2,825	4.5	127
Miss.	2,369	10.0	237
Ark.	1,373	49.0	673
La.	998	14.0	140
Okla.	1,319	40.0	528
Tex.	3,071	36.0	1,106

TABLE 34 * (*Continued*)

State	All Corn Acreage	Percentage Planted with Hybrid Seed	Indicated Hybrid Corn Acreage
	thousand acres	*per cent*	*thousand acres*
CORN ACREAGE PLANTED WITH HYBRID SEED, 1947 (*Continued*)			
Mont.	196	15.0	29
Idaho	24	60.0	14
Wyo.	73	8.0	6
Colo.	638	34.0	217
N. Mex.	160	9.5	15
Ariz.	34	3.0	1
Utah	25	62.0	16
Nev.	2	46.0	1
Wash.	17	69.0	12
Ore.	31	72.0	22
Calif.	60	41.0	25
U. S. total	86,424	71.4	61,690

* Bureau of Agricultural Economics, U. S. Department of Agriculture.

† Less than one-tenth of 1 per cent.

‡ Sub-total changed on report from "Corn Belt" to "North-central states."

§ No sub-totals given.

TABLE 35 *

CORN: MONTHLY MARKETINGS IN THE UNITED STATES

Crop Year Beginning October	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
1918–19	7.2	7.9	12.9	16.1	7.7	8.1	8.8	8.6	6.6	4.8	6.0	5.3
1919–20	5.4	8.9	14.6	12.6	9.2	8.5	5.7	7.4	10.3	5.3	5.4	6.7
1920–21	5.2	6.9	10.9	13.9	11.4	8.6	5.4	8.3	9.1	4.8	7.1	8.4
1921–22	6.5	6.4	12.1	13.5	12.1	7.3	4.6	7.4	7.3	6.6	7.3	8.9
1922–23	8.5	9.0	14.1	11.1	11.4	6.8	5.5	6.3	6.6	7.0	7.4	6.3
1923–24	5.6	10.5	12.4	13.0	13.4	7.5	6.1	5.9	6.0	6.7	6.3	6.6
1924–25	7.0	11.2	13.1	13.7	9.6	8.2	6.3	7.9	4.3	5.1	7.7	5.9
1925–26	5.9	9.3	14.7	12.1	10.4	8.5	5.3	7.1	8.2	5.7	6.2	6.6
1926–27	10.2	9.2	13.0	11.8	10.9	6.9	4.8	6.1	9.2	5.1	6.5	6.3
1927–28	6.3	8.7	15.6	13.9	11.8	9.0	5.4	6.7	5.4	5.9	5.9	5.4
1928–29	6.3	12.0	16.1	12.4	11.0	7.1	3.7	4.1	7.0	6.3	6.7	7.3
1929–30	6.9	9.2	13.3	10.8	10.5	7.3	7.0	6.9	6.3	6.0	7.9	7.9
1930–31	7.5	9.3	13.0	10.0	9.9	8.2	7.7	5.5	7.5	7.4	8.2	5.8
1931–32	7.6	9.9	11.2	10.2	10.4	7.6	7.4	6.4	5.4	6.2	8.6	9.1
1932–33	8.3	8.1	8.9	8.0	7.4	5.1	8.4	9.1	10.3	12.4	6.2	7.8
1933–34	8.8	10.9	9.6	8.0	6.5	6.7	3.6	5.1	6.4	10.8	14.8	8.8
1934–35	11.6	11.3	11.3	7.9	7.4	7.2	8.8	7.7	7.6	6.4	6.7	6.1
1935–36	6.8	12.2	10.7	10.4	6.7	7.0	8.3	8.7	8.0	7.6	6.3	6.7
1936–37	8.0	15.3	14.3	11.5	9.6	8.8	6.6	7.2	6.0	4.5	3.1	4.0
1937–38	5.4	8.6	9.7	8.2	8.4	9.8	8.2	8.6	9.6	8.4	8.7	5.7
1938–39	12.3	11.5	11.1	7.9	6.4	6.5	5.9	8.2	7.8	5.7	6.3	9.7
1939–40	11.5	13.7	11.0	7.8	7.6	7.5	7.2	7.4	5.9	5.7	6.4	8.0
1940–41	10.1	9.7	9.0	8.4	7.1	7.9	6.9	8.2	6.5	6.4	9.2	10.1
1941–42	7.2	10.0	9.7	7.6	7.1	6.9	8.3	7.2	8.5	9.2	8.8	9.1
1942–43	9.0	10.2	11.9	11.1	10.0	7.4	7.2	6.4	5.3	4.7	8.4	7.7
1943–44	9.6	11.7	12.8	15.7	13.0	7.1	4.2	5.0	6.8	4.4	3.8	4.7
1944–45	6.5	10.4	10.9	11.1	8.9	8.8	8.1	9.1	7.8	5.5	5.2	6.8
1945–46	8.4	12.0	12.9	15.9	11.8	7.2	5.1	5.2	3.3	7.9	4.9	4.1
1946–47	6.3	10.8	11.2	11.9	9.9	8.7	7.3	7.5	9.0	7.0	5.3	5.1

* Bureau of Agricultural Economics, U. S. Department of Agriculture.

TABLE 36 *

Corn: Utilization for Grain, Silage, Hogging Down, Grazing, and Forage, 1919–1947

Year	For Grain: Acreage	For Grain: Production	For Silage: Acreage	For Silage: Production	Hogging Down, Grazing, and Forage Acreage
	thousand acres	*thousand bushels*	*thousand acres*	*thousand tons*	*thousand acres*
1919	87,487	2,341,870	3,554	......	7,104
1920	90,149	2,695,085	3,682	......	7,528
1921	91,939	2,556,924	3,486	......	7,730
1922	84,858	2,229,496	3,663	......	11,824
1923	87,493	2,429,551	3,983	......	9,647
1924	84,119	1,899,751	4,906	......	11,995
1925	86,918	2,413,364	3,596	......	10,817
1926	83,097	2,133,404	4,346	......	12,009
1927	83,915	2,249,926	4,268	......	10,174
1928	85,821	2,282,938	3,996	......	10,519
1929	83,196	2,140,215	4,021	29,342	10,589
1930	85,465	1,733,429	4,845	30,461	10,773
1931	90,055	2,229,088	4,704	33,434	11,189
1932	94,585	2,514,613	4,063	30,816	10,020
1933	88,999	2,038,706	4,541	31,115	9,720
1934	58,432	1,104,657	6,678	33,466	22,685
1935	82,551	2,001,367	5,309	37,563	8,115
1936	67,833	1,258,673	8,539	33,690	16,782
1937	81,222	2,349,425	5,543	37,522	7,165
1938	82,788	2,300,095	4,456	35,187	4,916
1939	78,307	2,341,602	4,514	33,200	5,458
1940	76,443	2,206,882	4,735	34,615	5,251
1941	77,404	2,414,445	4,023	33,751	3,930
1942	79,213	2,801,819	3,841	33,445	4,313
1943	81,906	2,668,490	4,162	33,518	5,992
1944	85,019	2,801,993	4,471	34,822	4,524
1945	78,450	2,593,752	4,432	34,643	5,197
1946	79,711	2,989,887	4,555	35,767	4,452
1947	74,930	2,153,326	4,640	34,162	4,411

* Bureau of Agricultural Economics, U. S. Department of Agriculture. Compiled from records of the Division of Crop and Livestock Estimates.

TABLE 37 *

SWEET CORN, COMMERCIAL CROP FOR MANUFACTURE: ACREAGE, PRODUCTION, AND SEASONAL AVERAGE PRICE PER TON RECEIVED BY PRODUCERS, BY STATES; AVERAGE, 1933–1942; ANNUAL, 1943 AND 1944

	Acreage			Production in Husk			Price per Ton		
State	Average 1933–42	1943	1944	Average 1933–42	1943	1944	Average 1933–42	1943	1944
	acres	*acres*	*acres*	*tons*	*tons*	*tons*	*dollars*	*dollars*	*dollars*
Me.	11,770	13,600	13,000	43,700	49,000	41,600	16.00	28.00	29.10
N. H.	570	490	430	2,000	1,900	1,100	15.80	27.00	27.70
Vt.	1,090	1,020	960	3,000	3,100	2,500	11.50	22.00	22.00
N. Y.	20,010	24,700	25,100	45,700	56,800	45,200	11.50	19.20	22.00
Pa.	9,350	16,700	14,500	19,700	28,400	20,300	11.50	18.70	19.80
Ohio	22,060	27,600	22,400	44,000	63,500	33,600	8.60	17.20	17.90
Ind.	45,290	51,900	39,600	71,900	98,600	47,500	10.00	18.00	20.80
Ill.	65,920	72,700	65,200	149,000	181,800	117,400	9.50	17.20	20.20
Mich.	4,320	4,900	4,800	5,000	6,900	4,800	11.10	17.00	18.50
Wis.	27,220	74,100	82,500	61,600	177,800	198,000	9.00	17.10	17.50
Minn.	58,520	77,400	84,200	158,700	193,500	193,700	8.00	16.90	17.10
Iowa	35,420	57,700	47,900	78,000	144,200	100,600	7.50	17.40	18 60
Neb.	2,740	3,000	1,900	4,100	5,400	4,400	6.50	17.00	17.50
Del.	2,260	4,800	5,100	5,900	6,200	8,700	10.10	19.50	20.00
Md.	32,680	48,200	46,500	69,800	57,800	79,000	11.00	19.40	19.50
Tenn.	2,490	2,600	2,500	7,200	5,200	3,500	11.40	17.00	19.00
Wash.	2,950	11,200	12,000	10,300	40,300	40,800	11.50	23.30	23.70
Ore.	2,300	4,700	4,800	5,500	16,400	15,400	14.40	23.80	24.40
Other states †	7,100	12,800	15,050	18,000	33,800	41,900	9.77	19.82	20.41
Total	354,060	510,110	488,440	803,100	1,170,600	1,000,000	9.79	18.34	19.44

* Bureau of Agricultural Economics, U. S. Department of Agriculture.

† Arkansas, Colorado, Idaho, Kansas, Montana, New Jersey, Oklahoma, South Dakota, Texas, Utah, Virginia, and Wyoming.

TABLE 38 *

Sweet Corn, Commercial Crop for Manufacture: Acreage, Production, and Seasonal Average Price per Ton Received by Producers, by States; Average 1935–1944, 1945, 1946, 1947

State	Acreage				Production				Price per Ton			
	Average 1935–44	1945	1946	1947	Average 1935–44	1945	1946	1947	Average 1935–44	1945	1946	1947
	acres	*acres*	*acres*	*acres*	*tons*	*tons*	*tons*	*tons*	*dollars*	*dollars*	*dollars*	*dollars*
Me.	12,430	11,600	11,800	10,800	45,800	30,200	41,300	33,500	19.00	28.00	28.90	30.00
N. H.	540	410	410	390	1,900	1,200	1,800	1,600	18.40	27.40	27.70	30.50
Vt.	1,090	750	760	550	3,100	1,800	1,800	1,300	13.70	22.50	23.40	24.30
N. Y.	22,290	24,000	27,500	22,200	50,800	57,600	66,000	46,600	13.20	19.60	19.90	19.60
Pa.	11,610	12,600	12,200	11,600	23,200	26,500	22,000	23,200	13.40	20.50	20.70	22.30
Ohio	23,950	20,300	22,600	23,100	47,900	46,700	49,700	46,200	10.70	17.60	18.00	18.30
Ind.	48,180	39,200	32,000	44,500	78,800	74,500	64,000	89,000	12.20	19.70	20.80	19.40
Ill.	68,600	62,900	72,600	70,600	165,000	163,500	174,200	127,100	11.70	20.00	20.10	20.50
Mich.	4,560	2,900	3,300	3,000	5,500	3,800	4,600	3,000	12.60	17.00	18.10	18.10
Wis.	41,570	97,200	100,000	99,700	96,200	223,600	210,000	219,300	10.90	17.50	17.80	18.90
Minn.	66,500	86,300	81,700	76,800	179,500	181,200	228,800	169,000	10.10	17.20	17.20	18.70
Iowa	41,350	46,800	42,400	35,100	93,600	107,600	123,000	42,100	9.90	18.70	18.70	18.80
Neb.	2,760	2,700	2,400	2,100	4,300	7,000	6,300	2,700	8.60	18.30	19.10	18.10
Del.	2,740	4,100	5,900	4,700	6,300	9,800	14,800	12,200	12.20	19.40	20.00	19.40
Md.	36,880	38,400	39,500	37,700	74,900	88,900	86,900	82,900	13.10	20.20	20.00	20.60
Va.	710	700	440	500	1,100	1,500	1,100	1,600	15.70	19.50	20.00	19.70
Idaho	2,780	6,800	9,000	8,600	8,600	23,800	30,600	29,200	12.00	23.00	23.00	22.00
Utah	860	1,800	2,900	4,600	2,900	6,700	9,900	17,900	14.50	23.30	23.60	22.30
Wash.	5,220	11,900	15,800	12,000	18,600	38,100	56,900	43,200	14.30	21.70	25.30	27.10
Ore.	3,010	5,700	9,700	10,200	8,300	20,500	27,200	33,700	16.60	24.80	32.80	34.00
Other states †	7,880	6,810	8,000	6,650	19,600	17,700	21,200	17,300	12.19	17.81	17.76	18.47
Total	405,340	483,870	500,910	485,390	935,300	1,131,600	1,241,800	1,042,600	11.91	19.21	19.85	20.67

Bureau of Agricultural Economics, U. S. Department of Agriculture.

† Arkansas, Colorado, Kansas, Montana, New Jersey, Oklahoma, South Dakota, Texas, Virginia, and Wyoming.

TABLE 39 *

Corn, No. 3 Yellow: Weighted Average Price per Bushel of Reported Cash Sales at Chicago

Crop Year	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Average
	cents	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*
1916–17	98.0	92.0	98.0	100.0	109.0	140.0	159.0	170.0	199.0	206.0	210.0	203.0	111.0
1917–18	221.0	177.0	177.0	181.0	170.0	165.0	160.0	162.0	170.0	172.0	158.0	141.0	163.0
1918–19	133.0	145.0	143.0	127.0	153.0	162.0	174.0	178.0	192.0	195.0	155.0	141.0	162.0
1919–20	146.0	147.0	151.0	146.0	158.0	169.0	202.0	189.0	158.0	158.0	131.0	91.0	159.0
1920–21	77.0	75.0	65.0	63.0	62.0	57.0	60.0	62.5	60.0	56.0	53.1	45.2	62.0
1921–22	47.4	47.3	47.8	54.9	57.1	57.8	61.6	60.6	64.1	62.3	63.5	68.9	55.1
1922–23	71.1	72.7	70.1	72.5	72.9	78.7	81.5	84.0	87.7	88.0	88.6	104.4	73.4
1923–24	82.0	70.9	76.1	78.2	77.3	77.4	77.3	81.6	109.4	117.3	113.6	110.3	87.7
1924–25	111.5	120.4	123.8	122.0	116.8	105.3	115.4	112.8	107.5	102.0	90.6	82.2	106.4
1925–26	82.8	76.5	78.7	74.6	71.6	71.5	70.6	70.0	78.3	80.2	79.0	76.8	74.7
1926–27	70.6	75.1	74.0	72.7	68.5	71.1	86.7	98.9	101.9	109.2	97.4	84.4	86.7
1927–28	84.0	86.4	88.6	95.2	98.5	105.9	107.5	103.5	106.4	102.3	100.1	95.9	101.0
1928–29	84.4	83.4	93.1	94.4	94.1	89.8	87.4	91.1	98.8	101.2	100.6	94.5	92.5
1929–30	87.6	87.5	85.1	81.8	79.7	82.0	78.6	79.1	82.0	98.9	94.0	82.0	83.2
1930–31	70.9	69.5	65.4	60.7	59.8	58.3	56.2	57.7	56.8	45.7	41.8	38.1	59.6
1931–32	42.7	37.1	37.0	34.2	33.2	32.5	31.4	30.2	31.9	31.9	30.0	25.7	35.6
1932–33	24.9	23.0	23.6	23.1	25.7	34.5	42.2	43.4	55.8	51.0	47.5	40.2	35.4
1933–34	44.4	46.5	49.7	48.6	48.9	47.3	51.3	58.4	64.1	76.1	80.0	77.9	52.0
1934–35	83.4	93.3	90.8	87.7	83.3	89.0	87.6	85.1	84.8	80.6	83.2	82.0	86.3
1935–36	62.1	59.0	60.8	61.3	60.8	63.2	63.2	64.0	85.8	113.5	112.1	106.6	74.6
1936–37	104.7	107.2	112.2	111.2	116.0	135.0	134.9	122.4	118.4	104.5	105.9	66.1	117.7
1937–38	53.4	56.1	59.3	56.9	57.9	58.6	57.7	57.0	58.7	53.6	52.7	44.7	55.7
1938–39	46.0	51.0	51.5	48.1	47.5	48.7	51.2	51.2	48.0	45.0	54.0	48.3	48.9
1939–40	49.7	56.3	58.5	57.6	57.9	62.5	68.6	65.8	.....	66.0	64.5+	64.3	56.5
1940–41	64.5	61.5−	63.6	62.3	65.6	69.1	71.7	73.7	73.7	74.5+	75.1	69.5	67.3
1941–42	70.7	75.9	81.8	81.9	81.7	82.3	85.3	84.5	86.0	84.4	84.1	77.3	80.0
1942–43	80.5	89.4	96.5+	97.0	100.8	103.1	106.0	106.1	†	†	†	†	93.8
1943–44	†	113.4	114.2	114.6	†	†	†	†	†	†	†	114.2	114.3
1944–45	109.3	114.1	114.8	115.1	114.9	115.4	116.5	117.9	117.9	118.0	118.0	118.3	115.2
1945–46	116.8	†	116.5	†	†	†	144.8	152.8	216.7	193.1	189.4	181.9	192.4

* Bureau of Agricultural Economics, U. S. Department of Agriculture. Compiled as follows: November 1935–May 1942, from the *Chicago Daily Trade Bulletin;* June 1, 1942, on, from the *Chicago Journal of Commerce*. Average of daily prices weighted by car lot sales.

† No sales reported. O.P.A. base price of 106.5 cents effective April 14, 1943; new base price of 115.5 cents, December 6, 1943; 118.5 cents, March 4, 1946; 143.5 cents, May 13, 1946.

TABLE 40 *

Hog-Corn Ratios † Based on Local Market Prices in the United States

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
	bushels	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*	*bushels*
1910	12.2	12.0	13.6	14.4	13.3	12.9	12.2	11.6	13.0	14.2	15.1	14.9	13.3
1911	15.3	14.4	13.7	12.1	10.7	9.8	9.4	9.9	9.9	9.3	9.3	9.2	11.1
1912	9.1	8.8	8.6	9.0	8.4	8.1	8.3	9.1	10.1	12.0	13.2	14.1	9.9
1913	13.6	13.9	14.4	14.4	12.7	12.3	12.1	11.1	10.1	10.4	10.5	10.3	12.2
1914	10.8	11.3	11.2	10.9	10.3	9.9	10.1	10.2	10.2	10.0	10.4	10.2	10.5
1915	9.5	8.6	8.4	8.5	8.7	8.7	8.7	8.5	9.2	10.8	10.6	10.1	9.2
1916	9.8	10.5	11.4	11.5	11.4	11.0	10.9	10.6	11.1	10.4	10.0	9.8	10.7
1917	9.9	10.5	11.5	10.3	8.8	8.3	7.4	7.7	9.0	10.1	11.2	12.0	9.7
1918	11.2	10.3	10.1	10.2	10.3	10.0	9.9	10.4	10.8	11.0	11.5	11.3	10.6
1919	11.1	11.3	11.2	11.1	10.8	10.2	10.5	10.2	9.3	9.7	10.0	9.2	10.3
1920	9.3	9.2	8.8	8.4	7.6	7.1	7.8	8.5	10.1	13.0	15.1	13.3	9.8
1921	13.5	13.5	14.3	13.0	12.5	11.6	13.0	14.8	14.0	15.9	16.0	15.2	14.0
1922	15.4	16.4	16.3	15.1	14.9	14.7	14.4	13.4	13.2	13.4	12.1	11.3	14.4
1923	11.1	10.6	10.0	9.4	8.5	7.4	7.7	7.9	9.1	8.5	8.5	8.9	9.0
1924	9.0	8.5	8.6	8.6	8.5	8.1	6.7	8.0	7.7	8.7	8.7	7.9	8.2
1925	8.3	8.4	10.6	11.2	10.0	9.7	11.5	11.4	11.6	13.4	14.3	14.9	11.3
1926	15.8	17.2	17.5	17.5	17.8	18.7	17.7	14.7	15.8	16.2	17.3	17.0	16.9
1927	17.1	16.8	16.7	15.9	12.9	9.4	9.3	9.5	10.3	11.6	12.2	10.8	12.7
1928	10.4	9.6	8.7	8.4	8.6	8.5	9.4	10.2	11.7	11.3	11.3	10.4	9.9
1929	10.2	10.2	11.3	11.7	11.6	11.3	11.3	10.7	9.8	9.9	10.5	10.9	10.8
1930	11.4	12.2	12.8	11.7	11.6	11.5	10.9	9.5	10.3	10.7	12.4	11.5	11.4
1931	11.8	11.6	12.0	12.0	11.3	10.6	11.5	12.3	12.6	14.1	11.9	10.9	11.9
1932	11.2	10.9	12.1	11.4	9.8	9.6	14.1	13.4	13.5	15.0	15.7	14.5	12.6
1933	14.0	15.2	15.6	11.4	10.0	9.9	7.2	7.8	8.0	10.7	9.1	7.0	10.5
1934	7.0	8.5	8.2	7.4	6.5	6.3	6.7	6.3	7.8	6.8	6.7	6.0	7.0

1935	8.1	8.4	9.6	9.2	9.3	10.0	10.2	12.6	13.2	13.3	15.1	16.5	11.3
1936	16.7	16.8	16.3	16.4	14.3	14.5	11.4	9.5	9.2	9.4	9.2	9.5	12.8
1937	9.3	8.9	8.7	7.6	7.7	8.5	9.1	11.2	11.2	16.6	17.2	15.5	11.0
1938	14.5	15.0	16.3	14.7	13.9	15.3	15.9	16.1	16.8	17.4	18.1	16.0	15.8
1939	15.4	16.4	16.0	14.5	13.2	11.9	13.1	12.0	12.6	13.7	12.5	10.0	13.4
1940	9.7	9.1	8.7	8.4	8.4	7.6	9.2	9.2	9.9	9.8	9.9	10.3	9.2
1941	13.3	13.0	12.5	13.2	12.6	13.4	14.8	15.0	15.9	15.6	15.2	15.4	14.2
1942	14.7	15.5	16.0	16.9	16.3	16.3	16.6	16.9	16.4	18.2	17.7	16.5	16.5
1943	16.0	16.2	15.5	14.3	13.4	12.8	12.2	12.6	12.9	13.1	12.3	11.5	13.6
1944	11.3	11.4	11.5	11.3	11.0	11.0	10.9	11.5	11.7	12.2	12.7	12.6	11.6
1945	12.9	13.2	13.1	13.2	13.1	12.7	12.5	12.4	12.6	12.5	12.8	13.0	12.8
1946	12.8	12.8	12.5	12.2	10.6	10.1	8.6	11.6	9.1	13.5	18.0	18.6	12.5
1947	18.0	19.3	17.6	14.9	14.4	12.6	11.7	11.1	11.3	12.3	11.1	10.5	13.7
1948	10.9	11.2	10.3	9.4	8.8	10.6	13.0	14.2	15.3	17.8	18.0		
Average 1928–47	12.4	12.8	12.8	12.1	11.4	11.2	11.4	11.6	11.9	12.8	12.9	12.3	12.1

* Bureau of Agricultural Economics, U. S. Department of Agriculture.

† Number of bushels of corn required to buy 100 pounds of live hogs based on average farm prices of corn and hogs for the month. See page 328.

TABLE 41*

Corn, Yellow: Average Price per Bushel, by Months, in Buenos Aires

Year Beginning November	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Average
	cents	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*	*cents*
1928–29	96.8	93.4	97.7	96.0	89.5+	84.2	78.7	80.5+	90.1	86.8	86.7	84.5 †	88.8
1929–30	75.1	71.8	65.0	62.3	59.1	59.8	59.1	55.9	53.5	56.1	50.5	42.8	59.2
1930–31	34.2	33.2	29.2	30.6	34.8	33.4	30.2	30.3	29.6	26.5	23.5	25.3	30.1
1931–32	32.0	28.5	27.2	29.5	32.7	31.0	29.3	30.2	31.4	32.1	32.1	29.8	30.5−
1932–33	27.7	25.8	28.6	28.2	26.8	26.7	29.9	30.7	36.8	34.6	36.6	33.9	30.5+
1933–34	38.1	37.3	38.5+	43.4	47.4	39.7	39.7	43.3	47.5−	60.9	57.9	52.2	42.5−
1934–35	51.2	56.2	48.6	43.2	41.7	39.1	37.8	37.7	36.9	37.0	37.9	37.5	42.1

Year Beginning January	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1935–36	48.6	43.2	41.7	39.1	37.8	37.7	36.9	37.0	37.9	37.5−	36.7	37.2	39.3
1936–37	37.0	37.2	39.4	41.9	42.1	42.4	46.0	52.3	51.6	49.0	45.3	47.6	44.3
1937–38	49.8	53.6	55.8	52.6	55.6	52.4	55.1	54.2	55.4	60.1	64.6	73.4	56.9
1938–39	83.5	80.4	77.9	75.7	67.7	62.0	64.4	55.3	51.3	50.5	48.5	58.2	64.6
1939–40	58.1	52.4	54.8	49.8	48.1	49.8	46.6	46.7	51.3	52.9	53.9	52.6	51.4
1940–41	46.4	38.9	38.2	35.2	32.0	29.9	32.1	30.7	29.6	25.3	23.2	†	33.0
1941–42	†	†	†	†	†	†	†	†	†	†	†	†	†
1942–43	†	†	†	†	33.3	33.3	33.3	33.3	22.7	22.7	24.4	26.5	28.7
1943–44	34.8	46.9	43.9	43.8	46.5	48.2	50.7	50.9	46.4	45.8	40.8	35.9	44.6
1944–45	35.2	34.0	30.7	45.0	45.0	45.0	45.0	45.0	45.0	42.9	40.5	40.1	41.1
1945–46	44.2	46.5	47.0	53.9	66.8	66.8	66.8	66.8	66.8	66.8	66.8	74.6	61.1
1946	88.3	95.1	115.2	118.9	145.3	162.1	157.8	135.8	146.2				

* Monthly averages taken from *Boletin Estadistico*, Buenos Aires, Argentina. Compiled from the *Revista de la Bolsa de Cereales*, Buenos Aires, weekly average of daily quotations. (January 1935–July 1936). From July 1936 to date, compiled from *Boletin Estadistico*, Banco Central de la Republica, Argentina, Buenos Aires.

† Not available.

TABLE 42 *

CORN: SEASONAL AVERAGE PRICE PER BUSHEL AT LOCAL MARKET PRICES, 1910–1947

Year	Ohio	Ind.	Ill.	Minn.	Iowa	Mo.	S. Dak.	Neb.	Kans.	United States
1910	51	45	45	46	42	45	43	44	48	51.5
1911	65	62	64	53	60	65	57	62	67	67.8
1912	54	51	52	40	44	54	40	49	53	55.2
1913	66	64	66	54	61	75	57	64	76	70.3
1914	70	67	68	59	64	73	58	61	67	70.8
1915	70	65	66	64	63	68	57	58	63	67.6
1916	113	108	111	99	115	107	101	115	109	113.7
1917	145	135	130	127	130	140	126	137	151	145.6
1918	149	144	142	125	140	159	128	145	159	152.0
1919	148	144	147	130	134	155	126	132	149	151.3
1920	64	57	58	47	47	60	39	38	47	63.8
1921	55	48	47	41	41	53	36	37	43	51.8
1922	75	69	69	60	64	75	54	62	68	73.2
1923	82	73	78	67	75	82	66	67	72	81.4
1924	116	103	102	91	101	106	88	97	96	106.3
1925	64	59	64	58	60	72	63	63	67	70.1
1926	75	66	69	67	69	76	64	73	75	74.0
1927	93	86	85	75	83	87	68	74	72	84.7
1928	88	83	80	70	76	84	70	77	74	84.0
1929	80	77	76	67	73	87	64	67	73	79.9
1930	64	56	54	49	52	67	47	46	52	59.8
1931	30	25	25	33	28	32	31	30	28	32.1
1932	32	26	27	28	30	27	25	27	27	31.6
1933	50	47	50	44	50	45	47	41	44	52.0
1934	77	78	79	76	79	95	84	87	97	81.5
1935	62	57	64	54	62	72	50	61	73	65.5
1936	99	100	105	103	107	116	108	116	119	104.4
1937	51	45	47	43	44	51	44	51	56	51.8
1938	46	45	45	43	46	49	44	47	50	48.6
1939	54	52	52	50	53	55	51	56	58	56.8 †
1940	67	63	61	53	57	60	53	58	58	61.8 †
1941	78	76	74	65	72	77	65	67	73	75.1 †
1942	91	91	90	79	86	97	75	82	91	91.7 †
1943	110	107	106	99	99	114	98	103	110	112.3 †
1944	112	108	105	90	98	107	89	97	102	109.0 †
1945	127	122	121	108	123	133	110	113	123	127.0
1946	156	149	151	140	153	151	141	151	154	156.0
1947	216	216	222	208	215	224	204	212	221	216.0

* Bureau of Agricultural Economics, U. S. Department of Agriculture. Compiled from records of the Division of Crop and Livestock Estimates.

† United States prices are subject to change when state prices are applied to the revised production figures for 1939–1944.

The prices published in this table are actual seasonal prices and are, therefore, different from the estimated prices that were used in previous editions.

TABLE 43 *

Iowa Temperature in Degrees Fahrenheit, 1900–1946

Year	Mar.	Apr.	May	June	July	Aug.	Sept.
1900	30.7	52.2	63.2	69.7	73.4	77.4	64.4
1901	34.2	49.9	60.7	72.3	82.4	73.8	63.3
1902	39.1	48.2	63.8	65.2	73.1	69.1	59.1
1903	38.8	49.8	61.6	64.6	72.9	69.1	60.8
1904	34.8	44.1	59.5	67.1	70.6	69.1	64.0
1905	41.5	47.5	58.3	69.9	70.6	74.3	65.8
1906	27.1	52.5	60.8	67.9	70.9	74.1	67.2
1907	40.6	41.5	53.5	66.5	73.7	71.1	62.8
1908	37.9	50.5	59.4	67.1	73.0	70.0	67.9
1909	32.5	43.8	57.9	69.1	72.3	76.1	62.4
1910	48.9	52.5	55.4	69.5	74.5	71.9	63.2
1911	39.4	46.8	64.9	75.7	75.5	71.7	65.8
1912	24.9	49.9	62.7	66.2	74.6	71.0	62.1
1913	31.9	50.2	59.4	71.5	76.1	76.6	64.5
1914	34.7	48.6	62.2	72.2	76.6	73.7	64.5
1915	29.3	57.2	56.1	65.1	69.5	65.9	63.7
1916	35.2	47.1	59.9	64.5	79.7	74.0	62.5
1917	34.6	45.5	55.1	66.0	74.3	69.4	62.6
1918	42.9	44.8	64.9	70.8	73.1	76.0	58.6
1919	37.5	48.4	58.2	71.9	77.4	71.5	67.5
1920	38.0	42.4	59.4	70.7	72.3	69.3	66.5
1921	42.8	52.4	63.3	74.7	77.9	72.1	67.3
1922	38.3	49.9	63.4	72.2	71.5	73.8	67.1
1923	29.4	48.4	59.6	70.9	76.5	70.6	64.2
1924	31.9	50.5	54.1	66.8	70.2	71.7	59.1
1925	40.1	56.5	57.8	70.4	74.1	72.4	69.0
1926	32.1	46.1	64.5	66.2	74.8	73.5	63.0
1927	39.6	49.2	58.4	66.4	72.9	67.9	67.4
1928	38.9	44.3	62.6	64.5	73.9	72.7	60.5
1929	39.1	41.2	57.7	67.6	74.1	71.9	62.4
1930	37.3	52.1	60.2	69.0	77.9	74.4	66.3
1931	34.9	50.9	57.5	75.0	77.2	72.6	71.0
1932	28.4	50.0	62.3	72.0	75.8	72.2	62.2
1933	36.0	48.8	60.5	77.8	76.1	70.5	69.4
1934	34.4	50.4	69.6	77.2	79.7	73.4	61.0
1935	40.7	46.7	55.0	65.9	79.4	73.6	65.0
1936	39.2	45.9	66.2	70.1	83.4	79.2	68.0
1937	32.9	47.7	61.8	69.0	75.9	77.8	65.9
1938	43.7	50.3	59.5	69.2	76.5	75.7	66.8
1939	36.4	47.8	66.4	71.4	76.2	70.7	69.3
1940	31.6	47.5	58.4	71.3	76.7	70.7	65.8
1941	33.5	53.8	66.0	70.0	75.1	75.1	66.6
1942	38.3	54.8	59.3	69.7	74.3	72.2	61.4
1943	31.0	49.0	57.5	71.6	75.4	74.0	60.3
1944	30.3	45.0	64.6	71.7	72.6	71.8	64.3
1945	45.3	48.7	55.1	64.1	72.1	72.5	62.9
1946	47.0	53.9	56.5	69.8	73.8	68.9	63.2
1947	31.8	43.8	55.6	66.3	72.8	80.6	67.6

* Bureau of Agricultural Economics. Compiled from records of the Weather Bureau.

TABLE 44 *

IOWA RAINFALL IN INCHES, 1900–1946

Year	Mar.	Apr.	May	June	July	Aug.	Sept.
1900	2.06	2.67	3.31	3.98	6.15	4.65	4.98
1901	2.64	1.79	2.35	3.71	2.34	1.29	4.77
1902	1.45	1.71	5.39	7.16	8.67	6.58	4.35
1903	1.38	2.98	8.55	2.86	4.83	6.64	3.81
1904	2.18	3.63	3.78	3.45	4.41	3.43	2.78
1905	2.04	3.03	5.95	5.53	2.91	4.05	3.81
1906	2.34	2.42	3.54	3.92	3.04	3.95	4.16
1907	1.35	1.32	3.48	5.35	7.27	4.33	2.75
1908	1.58	2.24	8.34	5.66	3.66	4.77	1.20
1909	1.53	4.58	4.34	6.41	4.77	1.81	3.58
1910	0.17	1.48	3.41	1.99	1.86	3.88	3.59
1911	0.93	3.09	3.76	1.82	2.27	3.32	5.12
1912	2.01	2.66	3.33	2.74	3.71	3.78	3.98
1913	2.48	3.29	6.24	3.31	1.82	2.68	3.31
1914	1.69	2.52	3.31	5.57	2.27	2.19	7.88
1915	0.96	1.41	7.34	4.16	8.32	2.81	6.02
1916	1.57	2.62	4.93	3.71	1.78	2.58	3.89
1917	1.84	4.55	3.87	6.65	2.27	2.29	2.90
1918	0.63	2.32	6.87	5.29	3.17	3.61	1.87
1919	2.33	4.78	3.11	6.13	2.86	2.59	5.34
1920	3.02	4.59	3.26	3.56	4.22	3.35	3.30
1921	1.57	3.34	4.23	3.76	2.53	5.04	6.72
1922	1.97	3.06	3.53	1.82	6.31	3.06	2.03
1923	2.87	2.09	2.84	4.93	1.75	5.42	5.79
1924	2.65	1.38	1.71	8.10	3.67	5.35	3.13
1925	0.93	2.20	1.16	6.64	2.66	3.47	5.04
1926	1.06	0.91	2.76	4.52	3.72	3.80	9.76
1927	1.92	4.84	4.69	2.42	1.96	2.36	4.56
1928	1.44	2.24	2.47	5.38	4.34	6.42	3.08
1929	1.44	4.62	2.47	3.08	4.31	2.44	3.74
1930	0.89	2.67	3.72	5.83	1.49	2.42	2.31
1931	1.68	2.29	2.96	3.73	2.72	3.30	6.69
1932	1.46	1.96	3.99	5.17	3.12	7.10	2.05
1933	3.09	1.21	4.36	1.64	3.45	3.01	4.16
1934	1.09	1.07	1.02	3.49	3.85	2.84	5.07
1935	1.47	1.92	4.84	7.00	3.35	2.42	3.46
1936	1.02	1.10	2.91	2.85	0.51	3.48	7.22
1937	1.63	3.20	4.07	3.80	2.63	3.99	1.50
1938	2.35	3.66	5.45	4.67	4.24	3.82	5.67
1939	1.79	2.07	2.07	5.32	3.15	4.72	0.82
1940	1.72	3.22	2.07	3.56	4.57	6.44	0.94
1941	0.99	2.50	3.26	6.20	2.24	1.94	7.74
1942	1.96	1.06	4.70	5.93	4.89	3.17	4.13
1943	1.51	2.57	4.40	6.16	4.56	5.07	2.18
1944	2.58	4.55	6.13	5.88	3.73	5.88	2.25
1945	2.88	4.38	6.17	4.70	2.96	3.43	4.37
1946	4.18	1.23	4.45	6.41	2.45	3.56	4.94
1947	1.38	2.76	4.26	10.39	1.72	1.49	2.10

* Bureau of Agricultural Economics. Compiled from records of the Weather Bureau.

TABLE 45 *

OHIO TEMPERATURE IN DEGREES FAHRENHEIT, 1900–1946

Year	Mar.	Apr.	May	June	July	Aug.	Sept.
1900	32.9	50.1	62.9	69.8	74.1	76.3	69.3
1901	39.5	46.7	59.0	70.9	78.1	73.1	64.8
1902	41.9	48.2	62.6	66.9	74.0	68.9	63.6
1903	46.7	49.9	63.9	64.4	72.9	70.7	67.6
1904	39.7	44.4	60.7	68.4	71.4	68.8	65.5
1905	42.7	48.5	60.7	69.2	73.0	71.7	65.3
1906	31.3	52.1	61.3	69.8	72.1	74.6	68.9
1907	45.9	42.5	54.5	65.5	72.6	69.5	65.5
1908	43.4	51.0	62.8	69.2	73.9	71.2	68.0
1909	37.3	49.1	58.7	70.1	70.7	71.9	63.2
1910	48.2	51.5	56.0	65.9	73.8	71.4	66.3
1911	37.4	47.7	66.3	70.9	74.0	72.5	67.5
1912	32.9	51.9	62.5	66.6	73.4	69.2	67.4
1913	40.1	50.9	60.3	60.8	74.5	73.3	64.1
1914	36.0	50.1	62.2	71.1	74.0	72.8	63.4
1915	33.2	54.8	57.8	66.8	71.5	67.5	67.0
1916	34.7	49.3	61.8	64.7	76.9	74.4	63.7
1917	39.6	48.7	54.1	66.9	72.3	71.3	61.9
1918	44.0	48.7	66.4	68.8	71.3	76.6	58.4
1919	41.0	49.7	58.6	74.2	75.1	70.5	66.7
1920	41.7	45.8	58.3	68.9	70.4	70.3	66.5
1921	48.9	55.1	62.1	73.4	77.8	70.6	70.1
1922	42.2	52.6	64.0	70.9	72.9	70.5	68.2
1923	37.7	48.4	58.3	71.0	72.8	70.7	65.7
1924	36.2	49.8	54.6	68.0	70.3	72.0	60.8
1925	41.8	54.2	55.6	73.0	72.0	72.0	70.1
1926	33.2	44.4	60.5	65.9	72.9	74.0	66.6
1927	42.7	49.8	60.1	64.6	72.6	66.4	68.1
1928	38.1	46.5	59.1	65.0	73.7	74.0	61.6
1929	45.8	53.2	58.5	67.1	72.9	68.0	65.5
1930	38.3	52.1	62.8	70.0	75.6	72.0	67.7
1931	36.2	50.1	59.1	70.8	77.2	72.7	70.3
1932	33.7	48.5	61.6	71.0	73.7	72.8	66.0
1933	38.4	50.9	63.6	74.4	74.7	71.2	69.1
1934	35.3	49.5	64.1	76.0	78.6	71.9	67.8
1935	46.2	47.5	56.3	67.4	76.7	73.2	64.4
1936	43.0	46.2	64.1	70.3	77.0	76.1	69.3
1937	34.9	49.7	60.5	69.3	73.2	74.7	63.0
1938	46.1	52.8	61.3	68.5	74.2	74.9	65.7
1939	40.8	47.1	63.7	72.5	72.9	72.7	70.1
1940	35.3	46.5	58.6	70.6	73.3	72.8	62.9
1941	33.4	55.5	63.4	70.9	75.1	71.7	68.9
1942	42.2	54.5	62.5	71.2	74.7	71.3	64.4
1943	37.3	45.9	61.2	74.7	74.2	72.4	62.5
1944	36.7	48.2	66.7	73.1	74.3	73.7	65.0
1945	50.2	53.1	56.1	67.5	71.7	71.6	67.8
1946	50.5	50.8	58.9	69.0	72.7	67.0	65.7
1947	33.1	50.7	57.8	67.8	69.4	77.3	66.2

* Bureau of Agricultural Economics. Compiled from records of the Weather Bureau.

TABLE 46

Ohio Rainfall in Inches, 1900–1946

Year	Mar.	Apr.	May	June	July	Aug.	Sept.
1900	2.33	1.88	2.48	3.07	4.39	3.72	1.71
1901	2.56	3.35	3.79	4.40	2.68	3.26	2.63
1902	2.78	2.18	3.11	7.44	4.39	1.59	4.51
1903	3.63	3.99	2.99	3.98	3.38	2.83	1.46
1904	5.85	3.41	3.67	3.08	3.93	2.64	1.88
1905	2.62	3.17	5.81	4.71	3.78	4.61	3.45
1906	4.18	1.89	2.22	3.53	5.21	4.76	2.86
1907	5.79	2.84	3.46	4.53	5.63	2.64	3.77
1908	5.61	3.80	4.83	2.56	4.16	2.59	0.58
1909	2.79	4.13	4.79	5.85	3.78	3.61	1.70
1910	0.25	3.34	3.94	2.74	3.32	1.60	3.86
1911	2.31	4.46	1.66	3.91	2.46	5.43	4.89
1912	4.28	4.51	3.17	3.17	5.79	4.06	3.04
1913	8.30	3.35	3.51	1.99	5.40	2.52	2.88
1914	2.43	3.99	3.00	3.12	2.22	5.11	1.39
1915	1.44	1.43	4.01	4.39	6.35	4.55	4.53
1916	4.15	2.35	4.29	4.88	1.92	3.15	2.55
1917	3.67	3.38	4.17	5.01	3.88	2.69	1.86
1918	2.48	3.21	4.49	2.65	2.60	3.66	3.73
1919	4.04	3.15	4.78	2.88	4.05	4.45	1.89
1920	2.72	5.79	2.46	4.51	4.50	4.37	2.56
1921	5.97	3.90	3.20	2.81	2.93	4.21	4.30
1922	5.15	4.51	4.69	2.97	3.70	3.28	2.81
1923	2.99	2.60	3.59	3.93	3.57	4.34	3.19
1924	3.58	2.70	4.13	6.36	2.86	2.12	4.71
1925	2.61	2.07	2.63	2.85	4.71	2.36	3.71
1926	2.29	3.14	2.52	3.10	4.39	6.02	7.12
1927	3.84	4.24	4.75	3.69	4.61	2.56	2.15
1928	2.86	3.12	1.75	6.99	4.71	2.70	0.91
1929	2.81	4.73	5.53	4.05	4.76	2.94	3.10
1930	2.76	2.02	1.76	2.26	1.54	2.40	2.68
1931	2.17	4.46	3.08	3.54	3.99	5.11	4.06
1932	3.02	2.28	1.67	4.03	4.42	2.10	2.83
1933	5.79	3.82	6.71	1.82	2.55	3.65	4.71
1934	2.84	2.11	0.81	3.59	2.73	4.27	3.77
1935	3.51	2.04	5.08	4.00	5.00	6.23	3.01
1936	3.65	3.01	1.76	1.68	3.05	3.72	3.11
1937	1.61	3.85	3.73	6.05	4.26	3.30	2.46
1938	5.28	3.18	5.25	4.08	4.99	3.10	4.02
1939	4.09	5.00	1.25	6.55	4.15	2.02	2.08
1940	2.96	5.53	4.51	4.79	1.93	4.18	1.54
1941	0.97	1.70	2.60	5.91	4.15	3.35	1.61
1942	3.30	2.70	3.96	4.19	3.98	3.48	3.18
1943	4.44	3.12	6.39	3.37	6.01	2.88	1.83
1944	4.87	4.25	3.76	3.08	1.69	4.02	1.92
1945	7.20	3.97	4.72	4.91	3.57	1.98	5.30
1946	3.21	1.63	5.64	5.94	3.09	2.51	1.42
1947	1.68	5.31	5.82	5.55	3.79	4.38	3.37

* Bureau of Agricultural Economics. Compiled from records of the Weather Bureau.

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